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North Atlantic right whale, *Eubalaena glacialis*, with the Fernandina paper mill at Fernandina Beach, Fla., in the background. Photo: Florida Fish and Wildlife Conservation Commission (NOAA research permit #15488).

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From Sunrise to Sunset in the California Drift Gillnet Fishery: An Examination of the Effects of Time and Area Closures on the Catch and Catch Rates of Pelagic Species

LAURA C. URBISCI, STEPHEN M. STOHS, and KEVIN R. PINER

Introduction

The Pacific Fishery Management Council's Fishery Management Plan for U.S. West Coast Highly Migratory Species (NMFS, 2007) describes five fisheries for highly migratory species (HMS), defined by the combination of target species and gear type. The large-mesh California drift gillnet (DGN) fishery[1] is one of these five federally managed HMS fisheries, along with the albacore, *Thunnus alalunga*, surface-hook-and-line fishery, the tuna purse seine fishery, the deep-set longline tuna fishery, and the harpoon swordfish, *Xiphias gladius*, fishery.

California's HMS fisheries have generally declined from their peak in the 1960's, when the tuna purse seine fishery targeting Pacific bluefin tuna, *Thunnus orientalis,* was one of the largest tuna fisheries (Calkins, 1982). However, after the closure of the Mexican Exclusive Economic Zone (EEZ) to U.S. commercial vessels in the late 1970's, the U.S. tuna purse seine fleet largely disappeared (Hanan, 1983). Although the albacore surface-hook-and-line fishery (Dotson and Center[2]) appears to be operating near historical capacity, swordfish fleets have experienced a similar decline in recent years to that of the purse seine fleet in terms of participation, effort, catch, landings, and revenues.

The west coast swordfish fishery has primarily utilized three methods of fishing in recent decades: harpoon, shallow-set longline, and drift gillnet. A harpoon swordfish fishery has operated off the U.S. west coast since ancient times, with the modern fishery beginning around the early part of the 20th century. While having little bycatch, the inefficiency of this gear type resulted in much of the fleet switching to the DGN fishery in the 1980's (Coan et al., 1998). The DGN fishery was state-managed before 2004, at which point existing state regulations were incorporated into the Federal HMS FMP, but the permit system continued to operate under California state law.

In the 1990's a pelagic longline swordfish fishery operated off the U.S. west coast; however, shallow-set longline gear was not authorized as a legal gear for targeting swordfish off

[1]There are two other entangling net fisheries off the coast of California besides the large-mesh California drift gillnet fishery, including a set net fishery and the small-mesh drift gillnet fishery that targets white seabass, *Atractoscion nobilis*. Only the large-mesh fishery targets HMS sharks and swordfish.

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[2]Dotson, R. C. 1980. Fishing methods and equipment of the U.S. west coast albacore fleet. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Sci. Cent., NOAA-TM-NMFS-SWFC-8, 126 p.

ABSTRACT—The California drift gillnet fleet has operated off the U.S. west coast since it developed in the late 1970's. At its full extent, fishing effort ranged from the Southern California Bight north to Oregon. The fishery initially targeted pelagic sharks (family Alopiidae), but shifted targets in the mid-1980's to swordfish, Xiphias gladius, *due to the species' higher value and to the regulatory changes which created an economic advantage for targeting swordfish compared to thresher shark,* Alopias vulpinas. *Consequently the number of participants in the once-small fleet substantially increased. Conservation concerns over the entanglement of nontarget species, including sharks, sea turtles (family Dermochelyidae and Cheloniidae), and marine mammals, led to the enactment of a series of time and area closures over a period of 19 years to reduce the bycatch of those species. As a result, the fishery declined dramatically.*

This paper analyzes catch and effort data for the fishery to determine the effects of these management measures on targeted pelagic sharks and swordfish catch per unit of effort (CPUE). Unlike traditional catch-rate analysis, which seeks to standardize fishing effort heterogeneity to produce a measure of relative stock abundance, our analysis uses a linear regression of set-level catch counts on time and area combinations where fishing occurred over the full period for which data is available to estimate the effects of time and area closures on fishery catch rates while controlling for population abundance trends. Resampling methods are used to quantify uncertainty in the estimates. The analysis documents reduced common thresher and shortfin mako shark, Isurus oxyrinchus, *CPUE resulting from effort shifting out of higher to lower catch rate areas.*

Before the 2001 establishment of the Pacific Leatherback Conservation Area (PLCA) closure which eliminated most effort in the fishery north of Pt. Conception, the fishery operated from the Mexican territorial water border northward to Oregon. The cumulative effect of all enacted time and area closures was to concentrate fishing effort within the Southern California Bight, likely contributing to a decline in vessel participation. The socioeconomic impacts on the operation of the fishery and on the usefulness of drift gillnet CPUE data for stock assessments are discussed.

Figure 1.—Net reel and bumper-ball floats on a DGN vessel (Photo: Stephen Stohs, NOAA).

the west coast under the HMS FMP when it took effect in 2004, due to concerns over the level of endangered loggerhead sea turtle, *Caretta caretta*, interactions and over possible negative impacts of longline fishing on the quality of the recreational HMS fishing experience. The current range of participation within the EEZ in the west coast swordfish fishery includes groups of fishermen exclusively using either DGN or harpoon, as well as a group using both gears: DGN gear if fished overnight and harpoon used opportunistically to target swordfish individually at the surface by day.

Drift Gillnet Fishery Overview

The components and operations of DGN gear used to target HMS have remained relatively consistent from the onset of the fishery until the present, with only moderate changes in mesh size and set depths. Drift gillnet gear consists of a panel of netting that is suspended vertically in the water by floats with weights at the bottom (Fig. 1). One end of the net is fastened to the vessel and the other end of the net is left free to drift along the current. Fishing usually takes place in proximity to oceanic features that attract and hold fish, with the nets set perpendicular to currents, or across temperature, salinity, or turbidity fronts.

To further limit interactions with diurnally active protected species, nets are set in the evening and allowed to soak overnight. The average soak time is approximately 10 h with net retrieval beginning at sunrise. Large meshes (≥ 14 in) are currently required in the HMS DGN fishery to reduce bycatch of smaller, unwanted species and to optimize the catch of larger more desirable fishes, such as pelagic sharks and swordfish (NMFS, 2013). The requirement for a uniform large mesh size makes HMS DGN gear highly selective for pelagic market species such as swordfish; common thresher shark, *Alopias vulpinas*; and shortfin mako shark, *Isurus oxyrinchus*, as small or undersized fish are able to swim through the mesh unharmed, whereas excessively large fish are unable to penetrate the mesh sufficiently to become trapped (Jennings et al., 2009).

The concept of targeting pelagic sharks off the coast of California was inspired by the occasional incidental catch of sharks in the nearshore small mesh gillnets that targeted California barracuda, *Sphyraena argentea*, and white seabass, *Atractoscion nobilis* (Hanan et al., 1993). When it developed in the late 1970's, the DGN fishery originally targeted pelagic sharks in the nearshore waters of the Southern California Bight (SCB), but it shifted targets in the mid-1980's to swordfish due to the species' higher value and to the regulatory changes which created an economic advantage for targeting swordfish compared to thresher shark.

The fishery initially targeted common thresher and other large pelagic sharks; however, fishermen soon realized that their nets were also efficient at catching swordfish. Swordfish had nearly four times the market value (Bedford, 1987; Holts, 1988) and were abundant, making the take of swordfish a more profitable operation.

In the earliest years of the DGN fleet, swordfish catches were constrained by regulations linking the ratio of the landings of swordfish to sharks; nevertheless, the potential value of a swordfish fishery to California resulted in the easing of those restrictions in the early 1980's.

A shark conservation closure 75 nmi off the coast during the spring pupping season increased the economic advantage of targeting swordfish over pelagic sharks. The fleet responded to the changing incentives by subsequently shifting their primary target from pelagic sharks to swordfish and by increasing participation in the DGN fishery. The newly formed DGN fleet started with only 15 vessels but rapidly increased fleet capacity to around 230 vessels by 1985 (Hanan et al., 1993).

The burgeoning DGN swordfish fishery encountered conflicts with other fishing sectors and constituents. As the fishery expanded, the commercial harpoon fishery expressed concerns over reduced swordfish availability, and the recreational hook-and-line fishery expressed fears over bycatch of striped marlin, *Kajikia audax*. Inci-

dental catch of marine mammals, particularly California sea lions, *Zalophus californianus*, caught near the Channel Islands, brought conflicts with marine mammal advocates.

Increasing awareness of the importance of top predators to the California Current Ecosystem renewed concerns over the population status of large pelagic sharks. In addition, the coastal California DGN effort was confounded with large-scale high-seas gillnetting, which was widely believed to be a "dirty" and destructive fishing practice (Johnson et al., 2005; Bull, 2007). Given these concerns and the fact that very little was known about the population status or biology of thresher sharks (Berkson[3]), laws were enacted to regulate the DGN fishery.

Besides mandatory gear restrictions and bycatch reduction measures, including requirements for pingers and 6-fathom net extenders to reduce marine mammal interactions and for a minimum 14 in mesh size, the primary regulatory mechanism to reduce the take of targeted and bycatch species in the large-mesh DGN fishery has been the use of time and area closures (PFMC, 2011). In 1982, the EEZ within 200 nmi of California was closed from 1 February to 30 April.

Then in 1985, state regulatory measures were enacted in California to implement three major management changes: fishermen were only allowed to target thresher sharks in May, as DGN effort was not permitted within 75 nmi of the coast from 1 June to 14 August, and the area within 25 nmi off the California coast was off limits from 15 December to 31 January. The 75 nmi closure's timeframe was changed in 1989 from 1 May to 14 July and then was expanded in 1992 by extending the closure from 1 May to 14 August. This is sometimes referred to as the thresher shark closure, since its intent was to eliminate the direct targeting of thresher shark by DGN in time and area combinations of conservation concern (Table 1, Fig. 2).

[3]Berkson, J. M. 1985. A population analysis of the common thresher shark (*Alopias vulpinus*). Contract rep. to Calif. Dep. Fish Game, p. 16.

Table 1.—Key management changes within the DGN fishery. Data obtained from Hanan et al. (1993) and Fishery Management Plan and Environmental Impact Statement for U.S. West Coast Fisheries for Highly Migratory Species (PFMC, 2003).

Year	Management changes
1980	California establishes a nontransferable limited entry program, allows fishermen to retain swordfish, creates the logbook program, and establishes 6,000 ft as the maximum DGN length.
1982	California issues a moratorium on the issuance of new permits and establishes a requirement that each vessel can land no more swordfish than shark by weight per month from 1 May to 15 September (50–50 quota). The fishery closes from 1 February to 30 April within 200 nmi and around portions of the Channel Islands.
1985	Shark-swordfish quota is removed from California regulations.
1985	California reduces the thresher shark fishing season to 30 days in May; fishing is prohibited within 75 nmi off California coast from 1 June to 14 August, and from 15 December to 31 January the fishery is closed within 25 nmi of the California coast.
1989	California modifies the 75 nmi thresher closure to cover the period from 1 May to 14 July.
1990	Federal Fisheries Observer Program is established.
1992	California extends the 75 nmi thresher closure period from 1 May to 14 August.
1994	California caps new entrants to the fishery and only allows permits to be transferred.
1997	Federal MMPA requires vessels to use acoustic pingers and to place the float line at least 36 ft below the surface water.
2001	The DGN fishery is closed under the Federal Endangered Species Act to protect the leatherback sea turtles from 15 August to 15 November, covering an area north of Pt. Sur, including the offshore waters to Pt. Conception, and extending north to lat.45°N. A second Federal ESA turtle closure is implemented in the area south of Pt. Conception and is designed to protect the loggerhead sea turtles only during forecast or occurring El Niño events from 1 June to 31 August.
2002	California establishes a requirement for permit holders to purchase a permit every year to remain in the fishery, but permit holders are not required to land every year.
2004	Establishment of Federal fishery management plan for highly migratory species.

The last major time and area closures were established in 2001 when DGN fishermen were subsequently prohibited from fishing within a 160,000 nmi^2 quadrant called the Pacific Leatherback Conservation Area (PLCA) from 15 August to 15 November. Similarly, an area in the SCB was designated as a loggerhead turtle closure to protect the species during El Niño seasons when oceanic conditions increase the chances of their occurrence inside the west coast EEZ.

The DGN fleet has been monitored by observers nearly since the onset of the fishery, first by a limited California observer program (Hanan et al., 1993) and subsequently through a Federal Fisheries Observer Program established by the National Marine Fisheries Service (NMFS). Under the authority of the Marine Mammal Protection Act, federal observers were given the responsibility to record information on all species caught on observed sets of DGN fishing. In addition to collecting information on marine mammal interactions, the observers also collected high quality information on fishing behaviors and catch which is presumed to be less biased than information self-reported by fishermen on trip logs. Data from observers have been used not only to validate the self-reported logbook program (Walsh et al., 2005), but they also are often the focus of CPUE standardization for use in stock assessments (Walsh et al., 2009).

Limiting fishing effort through time and area closures to protect bycatch of nontargeted species can have unintended consequences on the catch rates of both the target and nontarget species. In this paper we document the effects of time and area closures on DGN fishery. We use a simple statistical approach to account for changes in population abundance to estimate the effects of time-area closures on catch rates. We examined the catch rates of four species that composed the majority of the DGN catch: swordfish; common thresher shark; shortfin mako;

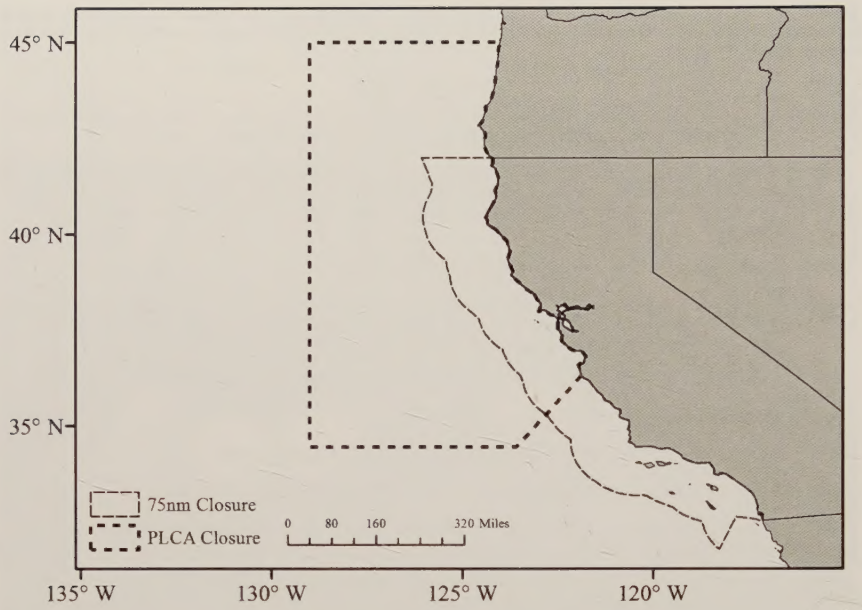

Figure 2.—The two main DGN fishery closures.

and blue shark, *Prionace glauca*. The discussion focuses on how regulations intended to protect sharks, marine mammals, and endangered seas turtles can have both intended and unintended consequences on commercial fisheries. We also address how management related shifts in fishing effort can result in misleading estimates of CPUE when they are used as measures of relative abundance without standardizing in the assessment to reflect the exogenous changes in the spatial-temporal distribution of effort.

Methods

Data

Data for this study include California Department of Fish and Wildlife (CDFW) issued DGN trip logbooks from 1981 to 2012 and data collected by the NMFS West Coast Region observer program from 1990 to 2013. Logbooks are self-reported data from captains; while compliance is high among fishermen who submit logbooks, not all fishermen return them. Observers provide records of fishery operations from a sample of slightly less than 20% of all trips, with fishery independent information provided by biologists who are trained to collect the data while onboard DGN trips.

Both datasets include information on the trip number, set number, date, effort, and catch counts for all thresher, shortfin mako, and blue sharks, as well as swordfish. The observer dataset contains latitude and longitude coordinates, while the logbooks provide the California Department of Fish and Wildlife block locations; hence the observer data are more fully representative of the exact locations of fishing effort and the spatial extent of the fishery, but they are limited to the less than 20% of effort with observer coverage since the program took effect in 1990. Both of the data sets had a small number of observations missing latitude-longitude coordinates. We did not believe these values would significantly impact our results, and hence we ignored the potential effect of missing observations on our results.

We conducted our analyses of thresher and shortfin mako sharks as well as swordfish using the logbook data, as catch counts for these commercially valuable species are presumed to be accurately recorded by captains. We used the observer data for blue shark, a less commercially valuable species with a lower retained catch rate, on the presumption that catch of species with limited commercial value and few landings may be underreported on trip logs.

Records from the logbook and observer data included for the study are for trips which used drift gillnet to target swordfish and HMS sharks. Although observer data represents only a fraction of the effort recorded in logbooks, observer records of undesirable catch are presumed to represent a more accurate measure of catch rates due to systematic inclusion of discards in observed catch counts.

Fishing effort (in sets) was categorized into areas and seasons corresponding to the time-area closures examined by our analysis. Observations were first filtered for missing latitude and longitude data needed for area determination.[4] For the remaining observations, the Haversine great circle distance measure was used to approximate the set location's distance from shore taking into account the curvature of the earth. We classified each observation as to whether it occurred within the area and during the time of either the thresher shark or PLCA closure based on location and date (Fig. 2).

Analysis

To estimate the effects of establishing the thresher shark closure and subsequent PLCA closure on the DGN fleet CPUE, we used linear regression analysis to estimate the set level catch rates corresponding to allowable effort that was either eliminated or continued under the time and area closures. Potential changes in species' abundance and nonclosure management measures implemented through time (Table 1) were accounted for by producing estimates using data over the full period

[4] 16,131 out of 122,880 logbook records (13.1%) were missing latitude-longitude or other key information, leaving 106,749 logs for swordfish, common thresher shark, and shortfin mako shark analysis; 202 out of 8,491 observer data records (2.4%) lacked latitude-longitude coordinates or other information, so 8,289 observations were available for blue shark analysis.

for which it is available. A resampling procedure was used to quantify uncertainty in the estimates.

$$y_i^k = \beta_{s(i)a(i)}^k + \eta_{t(i)}^k + \varepsilon_i^k$$

Where,

y_i^k = the number of fish of species k caught on set i,

$\beta_{s(i)a(i)}^k$ = the interaction term for species k given the season $s(i)$ and area $a(i)$ for set i,

$\eta_{t(i)}^k$ = the year effect for species k in year $t(i)$ when the i^{th} set was fished, and

ε_i^k = a white noise error term for species k on set i.

We resampled sets without replacement from all years, areas, and times that were open for fishing (1981–2010). On each simulation pass, a linear regression of catch rates on indicator variables for time and area of fishing and a fixed season effect was used to estimate time-area specific CPUE while controlling for time trends in CPUE.

Efron and Tibshirani (1994) discuss resampling methods for regression models, identifying two different ways of bootstrapping a regression model. Bootstrapping can resample the data set or the residuals of the linear model. The question of which method is better for a given situation depends on whether the linear regression model specification can be trusted. Our data may potentially depart from standard linear model assumptions about the independence of the error term if, for instance, different time and area combinations included in our model structure result in different error term distributions, violating the independence assumption of ordinary least squares regression. Hence we followed the suggestion by Efron and Tibshirani to bootstrap the original observations rather than the fitted residuals, thereby avoiding sensitivity of our results to linear regression model assumptions about the error terms which may not hold for our data.

To estimate the effect of each closure, we computed the mean of predicted CPUE for the portion of the resampled data representative of time-area combinations which remained open under the given closure policy. Mean catch rates for each species were computed for four scenarios: 1) no closure (corresponding to the pre-1985 period), 2) thresher shark closure in isolation (approximating the period from 1985 to 1999), 3) PLCA closure in isolation (hypothetical scenario not corresponding to any period that actually occurred), and 4) both closures in effect (corresponding to the post 2000 period). Because of some overlap in the areas of the thresher shark and PLCA closures, scenario 4 is not the sum of scenarios 2 and 3.

Results

The total DGN swordfish and HMS shark catches have declined almost linearly since the mid-1980's (Fig. 3), in close proportion to the decline in the total number of participating DGN vessels (Fig. 4). Shark catch rates outside of the time and areas closures are lower (Fig. 5). The thresher shark closure appeared to have the largest effect on thresher and shortfin mako shark catch rates, with both declining significantly (blue shark is not included in this discussion as observer coverage was not implemented until 1991).

Thresher and blue shark catch rates also declined with establishment of the PLCA closure in 2001, although the decrease for threshers is not as large as that which occurred with the thresher shark closure. In contrast, the swordfish catch rates increased with both the thresher shark and PLCA closures, but the magnitude of the effect of the PLCA closure was substantially less (Fig. 5).

The change in catch rates due to area closures may be explained by shifts in the location of effort (Fig. 6) relative to the location of high catch rates (Fig. 7). The thresher shark closure pushed effort farther offshore and also resulted in a northward shift of effort (above lat. 40°N). However the implementation of the PLCA closure severely shifted effort southward, largely confining effort to the SCB (below lat. 35°N). The shift of effort away from nearshore areas and to a lesser extent into the SCB moved fishing away from areas that had higher catch rates of large pelagic sharks. Thus the change in total catch of all species (Fig. 3) is a combination of decreasing effort

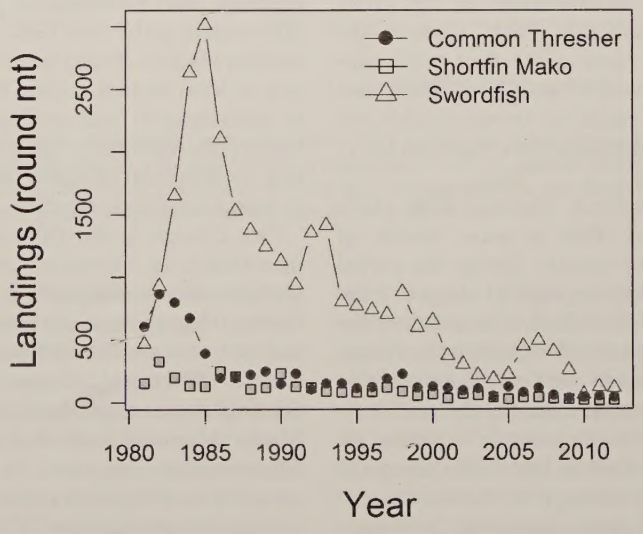

Figure 3.—Landings by species (round mt) from DGN vessels 1981–2012 (PacFIN). Blue shark landings are not included as they are often discarded.

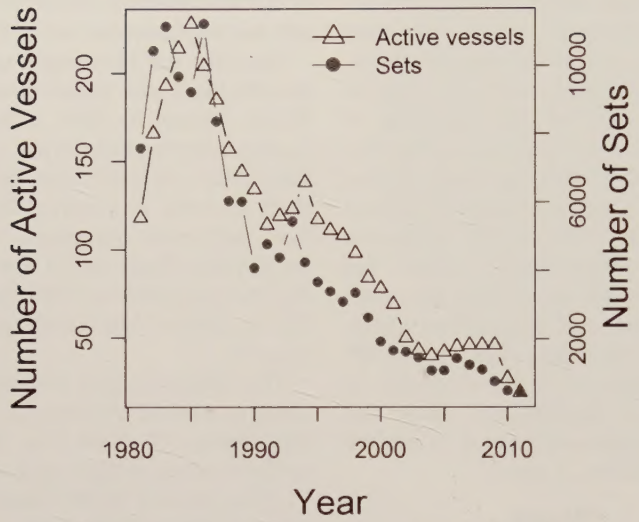

Figure 4.—The number of DGN vessels operating by year (left scale) and total number of sets fished per year (right scale) (Data from NMFS (2013) for set information from 1990–2011; data from Holts et al. (1998) for set information from 1981–89).

(Fig. 4) due to reduced areas open to fishing (Fig. 6) and, for some species, a reduced catch rate in the open areas (Fig. 5, 7).

Discussion

The reduction in times and areas open to fishing appears to have significantly impacted the structure and economic performance of the DGN fishery. Although DGN remains the sole U.S. west coast fleet with substantial levels of both HMS shark and swordfish catch, the levels of catch, effort, and revenues have declined in recent years.

Our analysis showed that shifting fishing effort to areas outside of the 75 nmi closure during the period from 1 June through 14 August (seasonal thresher shark closure) had the desired effect of significantly reducing the catch rate of large pelagic sharks, without reducing the catch rate of swordfish (Fig. 5). In contrast, restricting effort to the SCB during the 15 August through 15 November period due to the seasonal PLCA closure led to a smaller, though still significant, reduction in the thresher shark catch rate and an insignificant impact on the mako shark catch rate; however, there was an apparent reduction in the amount of effort inside the PLCA during the summer-fall portion of the season (Fig. 6).

Given a limited reduction in catch rates of the primary target species, swordfish, due to the closure measures and the precipitous decline in effort, landings, and participation from over 200 vessels in the mid-1980's to recent numbers below 20 and raises the question of what factors explain the decline in participation and production. We believe the decline is most likely due to a combination of many factors rather than a single explanation.

One change in the fishery since its inception is an increasing cost of regulatory compliance, such as the mandatory requirements to use pingers and 36' net extenders due to the 1997 Pacific Offshore Cetacean Take Reduction Team regulations under the Marine Mammal Protection Act. Since fishermen are required to bear the costs of such bycatch reduction technology, the profitability of DGN fishing is reduced, likely explaining some of the reduction in participation.

Spatial management effects on fishing operations have also likely contributed to the reduction in DGN fishing effort. Establishment of the PLCA not only reduced allowable fishing effort for a time and area combination where most of the historical leatherback sea turtle interactions occurred, but it also eliminated allowable effort in profitable time-area combinations with a favorable combination of high swordfish catch rates with lower transit costs, particularly for vessels ported to the north end of the fishery.

Increased fuel costs subsequent to establishment of the PLCA further squeezed the margin of profitability, particularly in light of the need for some fleet members to travel greater distances to access the swordfish stock. The availability of foreign imports as a cheap substitute for domestic production limited the fleet's potential to raise prices to cover higher transit costs. The differential effect of the PLCA closure on DGN vessels ported north, along the closed area, compared to those ported south of the closed area, suggests a hypothesis that DGN fishermen ported in areas with close proximity to closure areas saw larger drops in effort and participation than fishermen farther away. A disproportionally high impact of the regulatory cost of closures likely was borne by vessels with high shares of historic effort in time-area combinations which were disallowed by closures, as their remaining opportunities to successfully fish during closed seasons are either located in more distant waters, implying higher transit costs, or in less productive time-area combinations than those chosen before regulation. By contrast, fishermen ported farther away from closures, whose traditional fishing effort with respect to time and location remained open after time-area regulations, would be expected to bear less regulatory costs of lost opportunity to fish profitably; hence this group would be more likely to remain in the fishery.

The stable swordfish CPUE trend may reflect countervailing effects of declining vessel participation, due to reduced fishing opportunity, and sur-

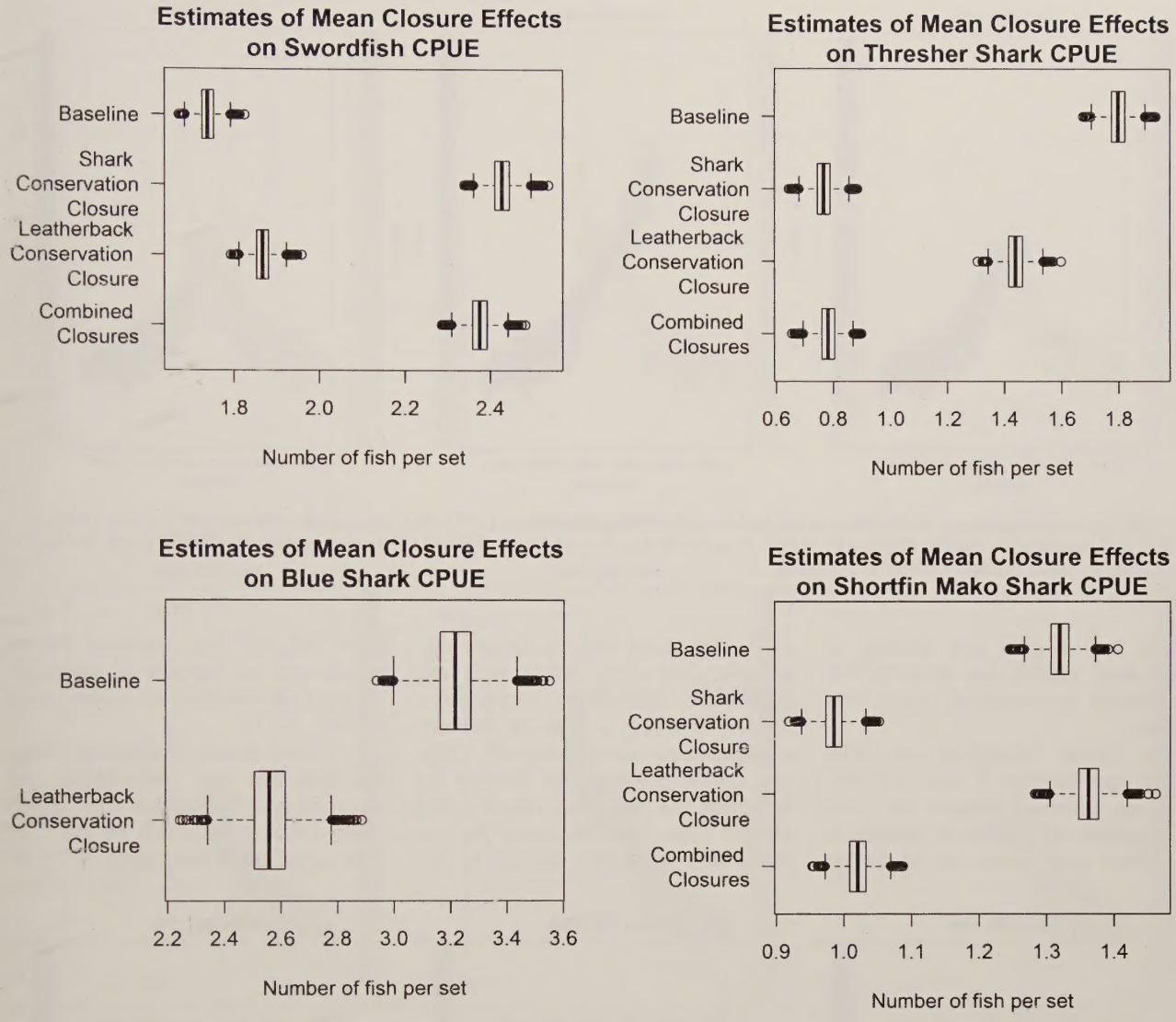

Figure 5.—Bootstrapped estimates of shortfin mako, thresher, blue shark, and swordfish CPUE under the shark area and PLCA closures, the combination of both closures, and no closure (baseline). Box-and-whiskers plots show the first, second (median), and third quartiles of bootstrap simulation estimates (hinges on box) with notches at +/-1.58 IQR/sqrt(n); outliers are displayed outside the notches. Individual panels have their own unique axes to maximize the interpretation of the boxes.

vival of the most efficient producers. Swordfish CPUE experience reflects selectivity bias, as the fishermen whose costs would have increased or CPUE would have decreased due to regulation dropped out while those who were able to maintain a favorable balance of CPUE and sales revenues against the costs of accessing the resource stock continued their participation.

While the limited entry permit system served to limit competition in the fishery and effectively established an effort control on finfish and bycatch impacts of DGN fishing, the requirement to renew DGN permits in each year or else lose them naturally leads to diminished fleet size over time. However, a large gap between the numbers of active permits and the total number of permits which could be fished indicates that a group of fishermen maintain hope that changes in regulations or other factors influencing economic viability could result in a restoration of profitable DGN fishing opportunity at some future point.

Although the effects of closures on all species' catch rates was mixed, the net effect of limiting seasonal availability of traditional fishing areas has been to dramatically reduce total fishing effort and catch from this fleet. These spatial fleet effects combined with California State measures capping the number of DGN vessels

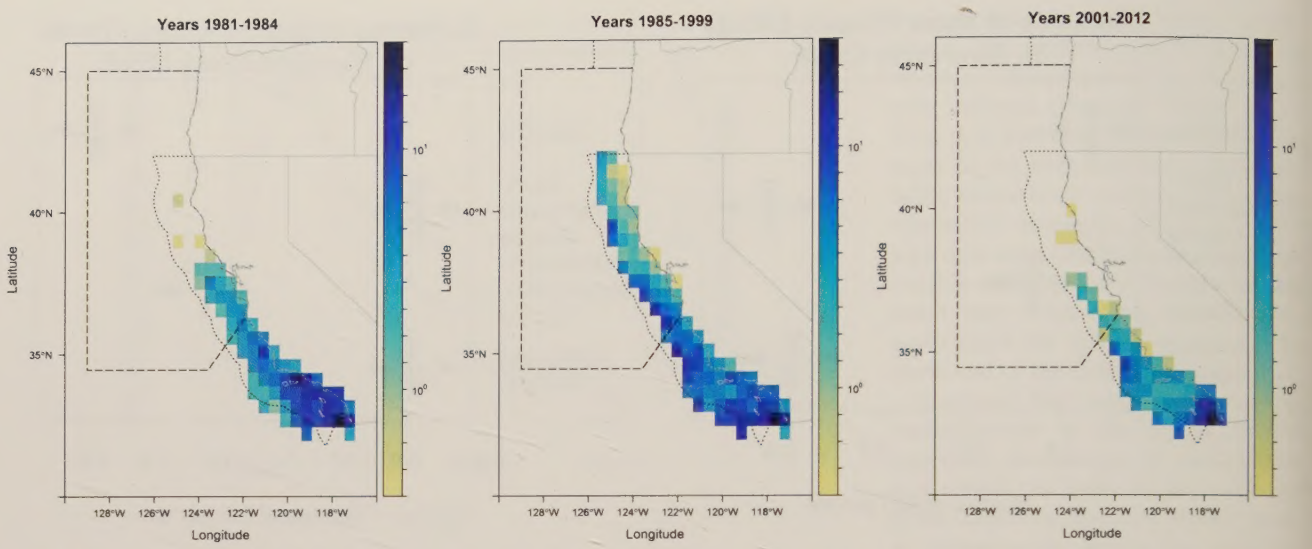

Figure 6.—Distribution of DGN effort in the period representing preclosure (1981–84), post-shark seasonal area closure (1985–99), and post PLCA closure (2001–10). Effort is given in 1x1 degree block. Effort is limited to extent of CDFW block coding system, so effort further offshore is excluded.

(1980) and capping new entrants to the fishery (1994) has ensured that the fishery participation could only decline.

The current limitations on DGN fishing opportunities is especially difficult on fishermen because the stock of swordfish off California appears to have been quite stable and above the levels associated with maximum sustainable yield (ISC, 2014). U.S. and worldwide swordfish consumption demand is strong as fears of mercury contamination have subsided (Lipton, 1986). However, this demand for swordfish has not been met by other west coast fisheries, given the lost production from the decline in the DGN fishery. The harpoon fishery has showed no increase in swordfish landings or revenues in recent years (PFMC, 2015).

A Hawaii-based shallow-set longline fleet that uses circle hooks and mackerel-type bait (Walsh et al., 2009) began landing swordfish on the U.S. west coast after reopening in 2004.

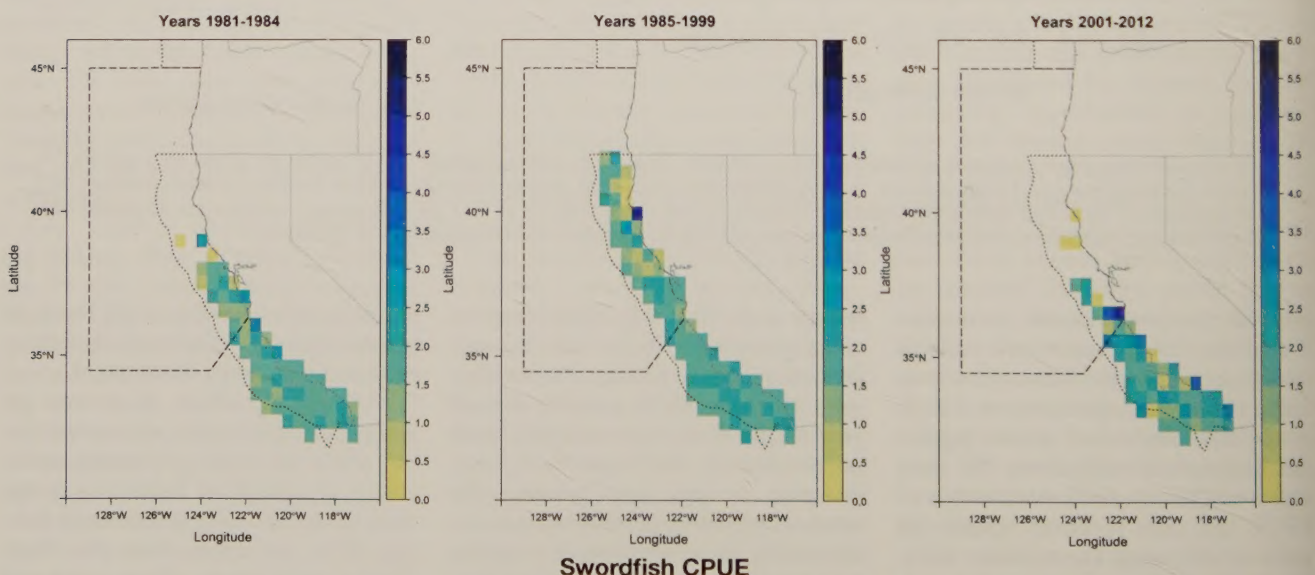

Figure 7.—Distribution of CPUE in the period representing preclosure (1981–84), post-shark seasonal area closure (1985–99), and post PLCA closure (2001–10). CPUE is given in 1x1 degree block for thresher, shortfin mako, and blue sharks as well as swordfish. Figure continued on next two pages.

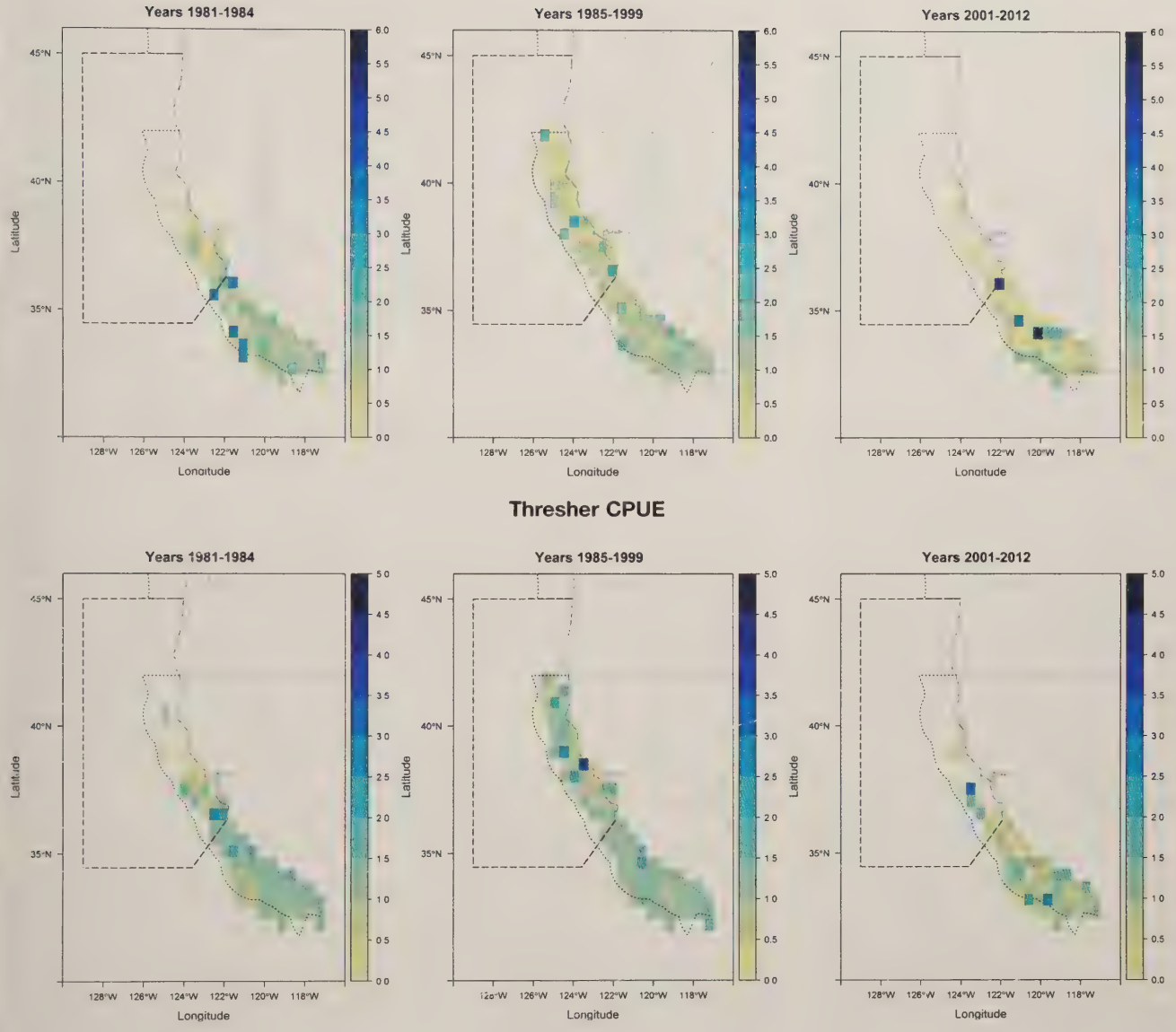

Figure 7.—*Continued.*

This gear combination has been shown to reduce the rate of endangered sea turtle interactions by nearly 90% from pre-2001 rates, but such gear was never approved for use in the West Coast HMS FMP (PFMC, 2015). Therefore any supply increase to satisfy unmet swordfish demand must have been due to imports.

The United States imports swordfish from a wide range of countries with potentially different attitudes toward conservation, including Canada, Panama, and Singapore. It is possible that restricting effort in the U.S. fishery may result in increased effort in foreign fisheries that may impose an even larger risk to the target stock and all bycatch species (Rausser et al., 2009).

In traditional stock assessments, catch rate data is typically used as a proxy for relative changes in stock abundance after appropriate standardization of changes in fishery practices (Maunder and Punt, 2004). In contrast, this work used a bootstrapping procedure to account for changing abundance to isolate the impacts of management measures on fishery catch rates. We included a fixed-year effect in our model to account for the influence of annual-level factors such as changing stock abundance and

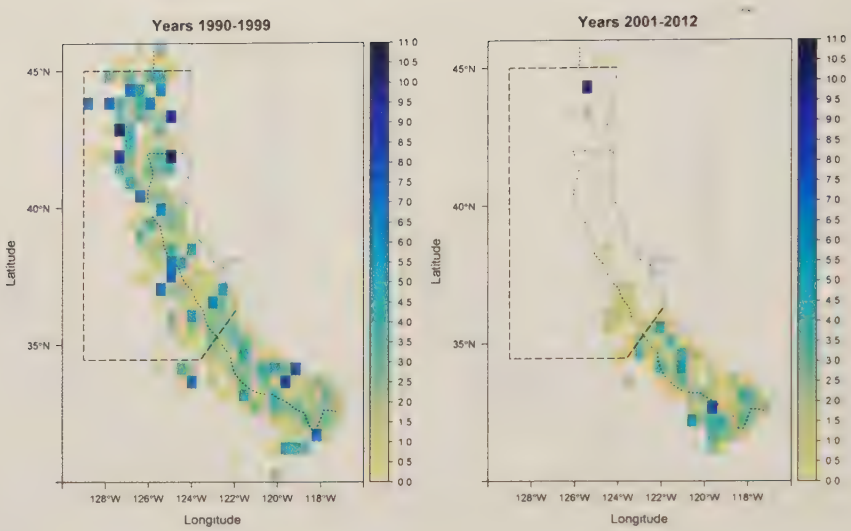

Figure 7.—*Continued.*

management measures not analyzed in this paper; however, we cannot be certain these were completely accounted for by the resampling methods.

Since each observation in our data represents a set-level catch count conditional on a single unit of closely-similar fishing effort, intrinsically limiting potential heteroscedasticity in the observation-level residual variance, we assume that heteroscedasticity is not a concern to our analysis. We also expect the potential efficiency gains due to modeling and estimating heteroscedasticity to be limited, given the weak correlation across time or space and the absence of any explanatory variable in our model which could potentially explain variation in residual variance. We further note that ordinary least squares is asymptotically efficient, and our sample size is very large.

A measurement problem of potential concern regards the confounding influence of removing the regulation requiring a fixed ratio of landed shark to swordfish on the effect of the thresher shark closure. Swordfish had, and continue to have, higher ex-vessel prices than the pelagic sharks, making them a more economically desirable species. Thus, the removal of shark to swordfish landing ratios likely also led to the reduced catch rates of threshers and increased catch rates of swordfish through the increased targeting of swordfish.

Beyond the impact of the regulations on the fishery, our analysis demonstrates the need to understand regulatory effects on a fishery when using CPUE as a proxy for relative abundance for stock assessment. This result applies to both targeted and nontargeted species. In the case of the DGN fleet, the primary influence of management regulations was a shifting of fishing effort into different areas as well changing the target of the fleet.

Some changes in spatial patterns appeared to influence catch rates while other shifts were not as influential. The spatial effects varied by species, making generalization of the effects of management difficult. It may be possible to standardize these spatial effects (Maunder and Punt, 2004), but the targeting effects might be more difficult to remove because they likely occur at a finer spatial scale. Of equal concern is the representativeness of the small number of participants left in the fishery and the reduced spatial areas fished of the entire target stock population range. The potential usefulness of the DGN fleet for providing population trend signals on pelagic stocks has likely dwindled with overall fleet capacity. Given public perceptions that drift gillnet is a high bycatch gear, the sun may finally be setting on the DGN fleet.

Acknowledgments

The authors thank California Department of Fish and Wildlife (CDFW) for developing the logbook program and the staff at the NMFS West Coast Region responsible for running the observer program that provided the data for this study. We also thank several scientists with both CDFW and the NMFS SWFSC for help in understanding and compiling the data. In addition, the authors thank several reviewers, both known and anonymous.

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Socio-economic Profile of the Small-scale Dive Fishery in the Commonwealth of Puerto Rico

JUAN J. AGAR and MANOJ SHIVLANI

Introduction

Commercial diving is the fastest growing and most valuable fishery in the Commonwealth of Puerto Rico (Fig. 1). Its share of landings rose from 14% in 1994 to 31% in 2014, while its share of revenues increased from 19% to 39% during the same period (NMFS, 2016). In 2014, divers reported harvesting slightly less than half a million pounds of shellfish and finfish with a dockside value of $2.3 million (NMFS, 2016).

The lure of commercial diving lies in its high earning potential and ease of entry. Divers can selectively target a diverse group of highly valued species such as queen conch, *Strombus gigas*; spiny lobster, *Panulirus argus*; miscellaneous reef-fish (Labridae, Scaridae, Lutjanidae); and octopus (Octopodidae) with modest capital investments in craft and fishing equipment.[1] Moreover, scuba equipment can be readily serviced around the island (Valdés-Pizzini, 1992).

In addition to low capital requirements, year-round warm weather and accessible facilities further encourage this activity (Valdés-Pizzini[2]). Additionally, divers do not face catch and gear theft problems associated with other fishing gears such as traps (Agar et al., 2008). However, they face greater health risks due to the potential for decompression sickness (bends), embolism, and shark encounters. Repetitive dives increase the incidence of bone necrosis, paralysis, and even death (Matos-Caraballo and Torres Rosado, 1989; González-Román, 1991; Lopez-Tristani et al., 2004).

In recent decades, fishery managers have become increasingly concerned about the health of queen conch, spiny lobster, and reef-fish populations in Puerto Rico, prompting them to adopt a number of regulations that included catch quotas, trip limits, seasonal and area closures, size limits, and miscellaneous gear restrictions. Surprisingly, little socio-economic research has been conducted on the dive fishery which is responsible for almost all of the queen conch revenues and close to 60% of the spiny lobster revenues (NMFS, 2016).[3] Moreover, the queen conch stock continues to be overfished. This paper describes the economic and social conditions of the commercial dive fishery to assist with policy development and evaluation. To the best of our knowledge, this study offers the first comprehensive view of the commercial dive fishery in Puerto Rico.

Methods

The data used in this study was derived from in-person interviews with commercial divers (hereafter "divers") and key informants, and secondary data sources which included governmental reports and databases. In total, we conducted 81 personal interviews with divers, which is over one-third (37%) of the population of "active" divers who report landings statistics (Table 1).[4]

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[1]In 2014, queen conch, spiny lobster, hogfish (Labridae), and octopus accounted for 42%, 40%, 5%, and 4% of the dockside revenues derived from diving, respectively (NMFS, 2016).

[2]Valdés-Pizzini, M. 2006. Trajectory of fishing gears in Puerto Rico: technological changes in local fisheries. Prelim. rep. submitted to the NMFS Southeast Fisheries Science Center, Miami, Fla., 51 p.

[3]The salient exception is Valdés-Pizzini (1992); however, his work focused mainly on the west coast of Puerto Rico.

[4]The sampling frame consisted of divers who reported landings at least once between 2011 and 2013.

ABSTRACT—This study provides the first comprehensive socio-economic profile of the small-scale dive fishery which is the most valuable commercial fishery in the Commonwealth of Puerto Rico. The study revealed that the fishery is composed of small-scale commodity producers who use labor intensive, low technology capital to catch high valued species such as queen conch, Strombus gigas; *spiny lobster,* Panulirus argus; *various reef-fish (Labridae, Scaridae, Lutjanidae), and octopus (Octopodidae). The average dive operation had a 20 ft, 76 hp fishing boat with 2–3 crew members. Diving operations fished 5 times a week for about 7 h. After deducting non-labor running costs, dive operations netted about $170 per trip. Fuel expenses accounted for about 61% of the nonlabor variable costs. Most of the crew members were non-kin because of the hazardous nature of diving which favors recruitment decisions based on skill and compatibility rather than kinship relationships. However, fishermen reported that diving accidents were not rare occurrences. Economic pressures and operational carelessness (rather than ignorance about diving risks) were cited as the main factors behind the accidents. Fishermen exhibited a high degree of occupational fidelity. Income sharing arrangements between boat owners and crew were found to be fairly egalitarian. The article underscores the need to explicitly consider safety at sea concerns when assessing the impact of management proposals.*

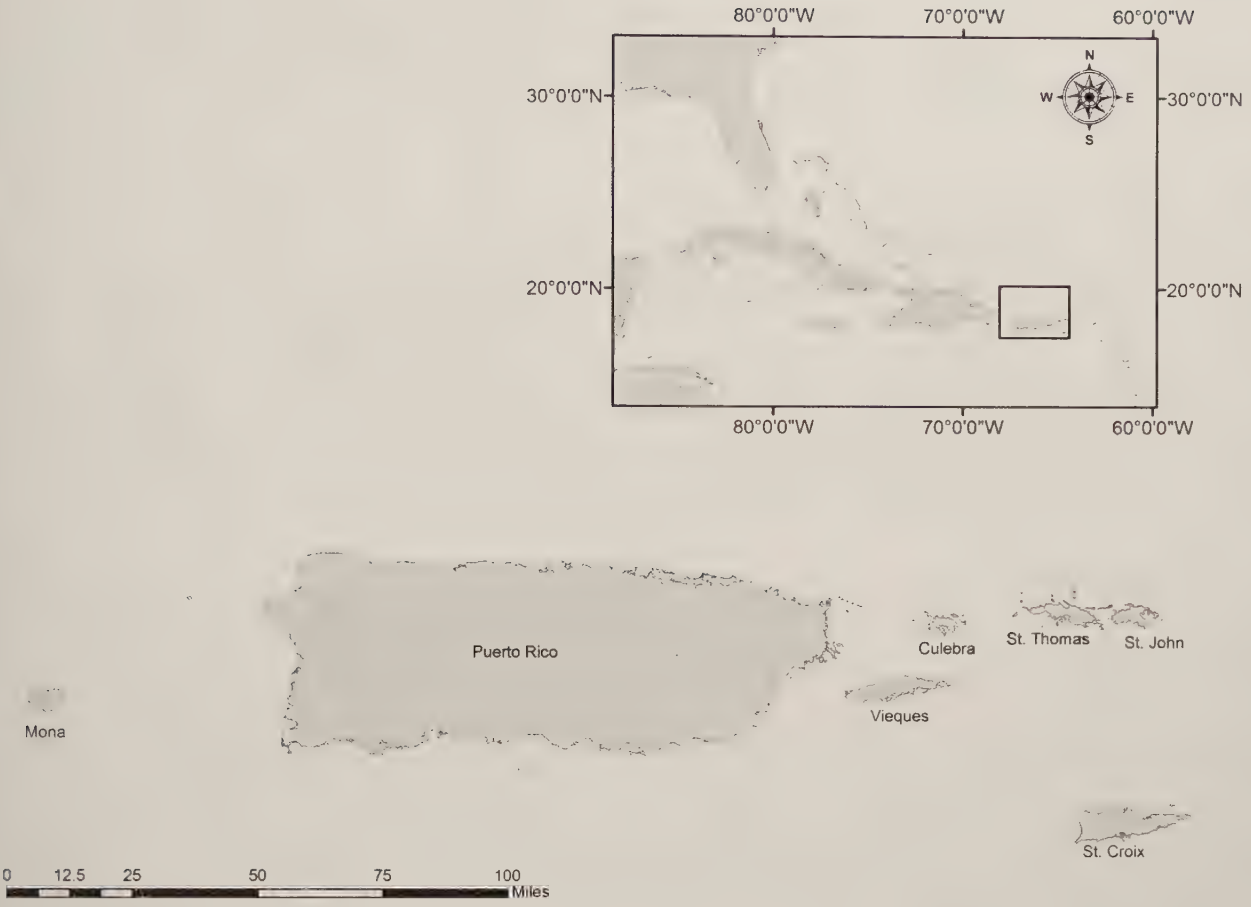

Figure 1.—The Commonwealth of Puerto Rico and environs.

Divers were interviewed using a standardized survey instrument that contained both closed and open-ended questions. The survey instrument collected information on demographics, capital investments (boats and fishing gear and equipment), fishing practices, and costs and earnings. In addition, it inquired about remunerative arrangements, crew organization and recruitment, and perceptions about the efficacy of the conch seasonal closure.

The survey was geographically stratified into four coastal areas: north, south, west, and east (Fig. 2).[5] The stratification helped capture the diversity of operations and made the data collection easier and more economical to administer.

[5]The northern region extends from the municipalities of Isabela to Luquillo. The eastern region runs from the municipalities of Fajardo to Maunabo, including the islands of Vieques and Culebra, and the southern region stretches from the municipalities of Patillas to Lajas. The western region spans the municipalities of Cabo Rojo to Aguadilla.

To satisfy the requirements of the sampling protocol, interviewers were instructed to select a replacement diver only if the one randomly selected either refused to participate in the survey; was unavailable due to illness, death, or travel; could not be contacted after six separate attempts; or was not identified by others at the fishing cooperative.

Despite the significant effort devoted to sampling, the unadjusted response rate was 58.3%. The unadjusted response rate was obtained by dividing the total number of completed interviews by the total number of people contacted (Table 1). Reasons for nonresponse included that divers could not be reached (35), no longer qualified because they no longer dove (10), gear misclassification (9), and

Table 1.—Sampling statisitics.

Regions	Diver population	Target number of interviews	Number of completed interviews	Number of nonresponses	Number of contacts
East coast	40	15	15	9	24
North coast	18	7	7	4	11
South coast	62	23	23	10	33
West coast	99	36	36	35	71

Figure 2.—Coastal municipalities in the Commonwealth of Puerto Rico.

refusals (4). The fieldwork took place between March 2014 and March 2015.

In addition, we conducted semi-structured interviews with key informants to help us contextualize our findings. Key informants included established divers, fishery managers and port agents, and professionals involved in research and outreach. Unless otherwise noted, the tabulated summary statistics are frequencies or sample means with their standard error in parentheses.

Results and Discussion

Demographic Profile

Most of the divers surveyed were Hispanic middle-aged men with extensive fishing experience and high levels of fishing dependence (Table 2). Their ages ranged from 24 to 80 years, averaging 49 years. Almost 83% of the divers were in the 40 years and over age bracket, and less than 4% of the sample was in the under 30 years age bracket. However, during our fieldwork we noticed many young divers, mainly high school and college-aged students, who reportedly do not turn in landings statistics (hence, they were not in our sample frame) probably because they fish on a part-time (or seasonal) basis. Therefore, the small share of those under 30 captured in our sample may not be indicative of declining recruitment rates but rather of the rise of nontraditional recruitment processes, which previously relied on kinship relationships (Valdés-Pizzini, 1992).

Staff from Puerto Rico's Fisheries Research Laboratory and established fishermen related that nowadays young divers usually start free diving with spearguns close to shore on a part-time basis, but once they become more proficient they begin scuba diving in deeper waters on a full-time basis. Most respondents were owner-operators and stated that, on average, they have been fishing for nearly 27 years (range 3–71 years).

Fishing was found to be an integral part of the household economy. On average, fishing income contributed close to 80% of their household income. Most interviewees indicated that they fished year-round on a full-time basis. Part-timers reported that they fished for income rather than for consumption purposes.

Divers spent, on average, 36 h per week on fishing and fishing related activities such as boat and engine maintenance and seafood marketing. Regional differences in participation and fishing dependence can be partially explained by geography (Table 2). For instance, the north coast has a narrow insular shelf and exposed coast that provides limited protection against rough seas which hampers fishing; however, the southwest coast has a shallow and extended shelf which makes fishing easier (Jarvis,

1932; Suarez-Caabro, 1979; Matos and Agar, 2011). The number of dependents (including the diver) ranged between 1 and 7, with an average of 3.6 whereas the Commonwealth's average was 2.7 (Table 2).

In addition to fishing income, many fishermen receive government transfer (welfare) payments and may participate in markets for wage labor (Valdés-Pizzini, 1985; Griffith and Valdés-Pizzini, 2002; Pérez, 2005; Griffith et al., 2007). Much of this wage labor is derived from low paying, casual occupations (i.e., odd jobs or "chiripas" as they are known locally). Reportedly, full-time divers mainly engage in "chiripas" during the queen conch closure.[6]

Pérez (2005) notes that "chiripas" can play an important role in supplementing household incomes. Government transfer payments such as food stamps; health, utility, and housing subsidies; and social security are also important supplemental sources of household income. Over 70% of the divers surveyed declined to describe their involvement in nonfishing activities, probably because they feared that sharing this information could threaten their access to welfare programs.[7,8]

The remaining divers reported that they worked in miscellaneous jobs such as construction, fish sales, boat maintenance, plumbing, landscaping, and waiting tables, among others. Aside from diving, respondents also stated that they fished with handlines, traps, vertical lines, and miscellaneous nets, and that spiny lobster, queen conch, and various reef-fish were their mainstay species (Table 3). About 75% of the divers said that they primarily fished in Commonwealth waters (<9 nmi).

Table 2.—Demographic profile by coastal area.

Variable	East coast	North coast	South coast	West coast	Island-wide	Number of respondents
Fishing role (%)						81
Captain-owner	93.3	85.7	73.9	80.6	81.5	
Hired captain			13.0	8.3	7.4	
Crew	6.7	14.3	13.0	11.1	11.1	
Age (years)	50.3 (1.9)	48.7 (4.0)	46.1 (2.0)	50.6 (1.5)	49.0 (1.0)	81
Age distribution (%)						81
<30 years			4.4	5.6	3.7	
30–39		28.6	26.1	8.3	13.6	
40–49	60.0	28.6	39.1	33.3	39.5	
50–59	20.0	14.3	13.0	36.1	24.7	
60–69	20.0	28.6	17.4	11.1	16.1	
>=70				5.6	2.5	
Fishing experience (years)	29.9 (3.2)	15.1 (6.3)	22.7 (2.4)	29.9 (1.8)	26.5 (1.3)	81
Fish year-round (%)	100	100	91.3	97.2	96.3	81
Full-time (%)	86.7	71.4	91.3	85.7	86.3	80
Time spent on fishing activities (h/wk)	44.4 (4.3)	39.9 (6.5)	36.6 (2.0)	31.7 (1.0)	36.2 (1.2)	78
Household income derived from fishing (%)	78.7 (7.2)	67.6 (14.6)	78.3 (5.0)	82.4 (3.6)	79.4 (2.8)	79
Number of dependents	3.0 (0.2)	3.7 (0.6)	4.0 (0.3)	3.6 (0.2)	3.6 (0.1)	81

Capital Investment in Boats, Fishing Gear, and Electronic Equipment

Most boats were relatively small and had limited technology (Table 4). The average boat was about 20 ft (13–27 ft range) powered with a single outboard gasoline engine, averaging 76 hp (8–300 hp range).[9] Most hulls were made of fiberglass and, to a lesser extent, of a combination of fiberglass and wood, or simply wood.[10] On average, divers valued their used boat and engine at $7,556 and stated that annual maintenance costs were about $1,750 (Table 4).

In addition to the boat and engine, diving, electronic, and safety equipment are important components of the capital stock held by divers (Table 4). Divers valued their diving equipment (i.e., tanks, regulators, spearguns, etc.) at about $1,148 and spent $293 annually on its maintenance. They also estimated that their electronic (e.g., cellular phones, global positioning systems, radio, and fish and depth finders) and safety equipment (e.g., personal flotation devices, fire extinguisher, etc.) were worth about $703 and $246, respectively.

Fishing Practices

Diving operations reported mainly targeting queen conch, spiny lobster, and/or various reef-fish. Most diving operations fish every day for 6–7 h and have a small crew of 2–3 (Table 5). Fishing excursions usually start early in the morning (around 5–6 a.m.) and end at noon or early in the afternoon (12–2 p.m.) before the wind picks up. Aggregate landings ranged from 15 to 225 lb per trip, averaging about 56 lb (Table 6).

[6]Daniel Matos-Caraballo from Puerto Rico's Fisheries Research Laboratory. Personal commun., March, 2016.

[7]Krueger et al. (2015) report that a 3-member household that receives food stamps, Aid to Families with Dependent Children (AFDC), Medicaid, and utilities subsidies can collect $1,743 per month, which is significantly higher than the $1,159 that a minimum wage earner could earn. Moreover, the Bureau of Labor Statistics (2017a) reports that the 2014 median hourly wage rate for an individual employed in farming, fishing, and forestry occupations in Puerto Rico was $8.96, which translates to a median monthly wage of $1,434 which is lower than the above-mentioned welfare payments.

[8]Agar et al. (2005) report that Puerto Rican fish trap fishermen were also unwilling to share information on their nonfishing activities.

[9]Valdés-Pizzini (1985) reports that in the 1980's the Puerto Real-based dive fleet was made up of 15–21 ft boats powered with 40–125 hp outboard engines.

[10]A port agent observed that rudimentary boats found on the west coast (mainly wooden or fiberglass-wood hulls) are called "Dominicanos" because they were left behind by undocumented Dominican immigrants after crossing the Mona Passage.

Table 3.—Main fishing gears and target species by coastal region.

Variable	East coast	North coast	South coast	West coast	Island-wide	Number of respondents
Percentage of fishermen who use the following gear (%)						81
Vertical line		14.3	21.7	13.9	13.6	
Longline				2.8	1.2	
Handline	26.7	42.9	52.2	33.3	38.3	
Shark longline			4.4		1.2	
Rod and reel			26.1	2.8	8.6	
Troll		14.3	21.7	5.6	9.9	
Fish and lobster trap	26.7	14.3	17.4	8.3	14.8	
Trammel net	13.3		8.7	5.6	7.4	
Cast net			17.4	8.3	8.6	
Beach seine			13.0	8.3	7.4	
Gillnet	6.7			2.8	2.5	
Percentage of fishermen who target the following species (%)						81
Deep-water snapper–grouper	13.3	71.4	82.6	77.8	66.7	
Reef-fish	100	57.1	91.3	58.3	75.3	
Dolphin/Wahoo		14.3	30.4	13.9	16.1	
Tuna		14.3	8.7	8.3	7.4	
Shark		14.3	17.4	8.3	9.9	
Lobster	100	85.7	100	100	98.8	
Conch	100	42.9	100	100	95.1	
Baitfish			17.4	13.9	11.1	
Ornamental fish						
Miscellaneous species	26.7	28.6	91.3	52.8	56.8	
Percentage of fishermen who fish in the following waters (%)						81
Territorial waters	100	100	78.3	58.3	75.3	
Federal waters						
Both			21.7	41.7	24.7	

Diving teams are composed of a helmsman (or boat tender) and one or more divers (Valdés-Pizzini, 1985; Appeldorn, 1997). The helmsman is responsible for navigating, hauling the catch, and tending the boat to ensure the safety of the divers who are fishing underwater (Valdés-Pizzini, 1992). About 90% of the owner-operators in our sample were divers. Divers reported using 2–3 air tanks each per trip, although some used as many as 6 tanks. Diving depths ranged from 10 to 150 ft.

Diving is a dangerous and potentially life-threatening activity. Respondents were aware of the causes and dangers of decompression sickness (or "burbuja" as it is locally known) but offered a number of explanations for (wittingly or unwittingly) disregarding safety guidelines. The two most commonly cited reasons were economic pressures followed by operational carelessness. They explained that they were more liable to take additional dives and/or prolong dives if poor weather conditions had prevented them from fishing in recent days or if the first few tanks were unproductive. They also mentioned that divers are tempted to dive longer if they find productive aggregations in the latter part of the trip. Some divers reported using a fourth tank to catch conch in 70–90 ft depths.

Divers also cited fatigue, overexertion (due to strong currents), overconfidence (especially by younger divers), equipment failure, and improperly accounting for residual nitrogen during multi-day and multi-tank dives for the increased risk of decompression sickness. Surprisingly, many divers reported going diving the next day after experiencing a "mild" bends event (or "chispitos" as locally known); however, they added that in these cases, they generally dove in shallower waters and for a shorter period of time for a few days.

A key informant mentioned additional factors that place the health of divers in danger.[11] He noted that many divers do not have diving licenses which forces them to refill their tanks in places with poor air quality because compressors may not work properly or are housed in places with poor ventilation. Additionally, some divers are habitual consumers of alcohol and drugs which impair their judgment and physical performance. It was also noted that many divers do not have medical insurance for work related accidents. The first treatment in a hyperbaric chamber (with helicopter transportation) can cost up to $10,000. Moreover, injured divers seeking treatment waste valuable time by initially going to local emergency rooms, which have limited experience with diving-related accidents, rather than going directly to medical centers with hyperbaric chambers.

Divers use a variety of fishing equipment to target a diverse and variable resource base. Besides using their hands to harvest conch and lobster, divers may also employ snares to catch lobster and gaffs to catch octopus (and occasionally to illegally catch lobster). Spearguns are also used mainly to catch various reef-fishes such as, snappers (Lutjanidae), hogfishes (Labridae), and triggerfishes (Balistidae), but sometimes they are unlawfully used to harvest lobsters.

Depending on the species pursued, divers may operate over a wide range of habitat types. For example, divers targeting queen conch gather them on seagrass beds and sandy bottoms, whereas those targeting spiny lobsters and reef-fishes catch them on hard bottoms and reef areas. Once a suitable queen conch aggregation is located, divers usually shuck the conch underwater and load the meat into baskets or mesh bags, which are lifted using a winch (or manually) and emptied onboard.

Conchs are usually shucked with a hatchet or hammer and chisel (Appeldorn, 1991).[12] Divers dislike shucking onboard (or on land) because of the added physical exertion of gathering and raising live conchs onboard and the added load of the shells which

[11] Ruperto Chaparro Serrano, Director of the Puerto Rico's SeaGrant Program. Personal commun., April, 2016.

[12] According to one of the most seasoned divers in the south coast, Dominican inmigrants were the first ones to shuck conchs underwater in Puerto Rico.

Table 4.—Vessel characteristics by coastal region.

Variable	East coast	North coast	South coast	West coast	Island-wide	Number of respondents
Boat length (ft)	19.9 (0.5)	20.3 (0.7)	19.1 (0.5)	19.6 (0.3)	19.6 (0.2)	81
Engine propulsion (hp)	68.9 (6.1)	85.7 (14.6)	93.8 (13.0)	64.6 (4.7)	75.9 (4.7)	81
Hull type (%)						79
Fiberglass	100	71.4	77.3	85.7	84.8	
Wood		14.3	4.6	8.6	6.3	
Fiberglass and wood		14.3	18.2	5.7	8.9	
Percentage of engines						81
Single	86.7	85.7	95.7	91.7	91.4	
Twin	13.3	14.3	4.4	8.3	8.6	
Engine type (%)						81
Inboard				5.6	2.5	
Outboard	100	100	100	94.4	97.5	
Fuel type (%)						81
Gasoline	100	100	100	94.4	97.5	
Diesel				5.6	2.5	
Value of used boat and engines ($)	8,346.2 (1,299.3)	7,700.0 (2,568.9)	8,175.1 (1,556.5)	6,822.7 (931.7)	7,556.2 (694.5)	73
Annual maintenance costs (incl. engines, $)	1,656.7 (498.0)	1,157.1 (370.7)	2,173.7 (516.3)	1,636.7 (305.9)	1,750.2 (222.8)	71
Diving equipment (%)						
Spearguns	93.3	85.7	87.0	82.9	86.2	80
Gaffs	13.3	0	60.9	14.3	26.2	80
Snares	93.3	57.1	56.5	77.1	72.5	80
Electronic equipment (%)						
GPS	53.3	57.1	26.1	68.6	52.5	80
Winch		28.6	4.4	5.7	6.3	80
Depth finder	13.3	42.9	13.0	20.0	18.8	80
Fish finder	13.3	57.1	13.0	5.7	13.8	80
Radio	13.3	71.4	13.0	14.3	18.8	80
Cellular	100	100	81.8	79.4	85.9	78
EPIRB		14.3		5.7	3.8	80
Value of diving equipment ($)	1,170.0 (198.6)	1,464.3 (637.3)	1,097.3 (137.4)	1,110.6 (129.1)	1,148.2 (95.4)	76
Value of safety equipment ($)	235.7 (29.1)	225.7 (58.5)	219.2 (23.1)	273.6 (25.2)	246.3 (14.8)	76
Value of electronic equipment ($)	426.7 (113.9)	1,917.1 (704.9)	486.9 (132.2)	752.0 (141.0)	702.5 (95.9)	76
Maintenance costs of diving equipment ($/yr)	189.0 (39.2)	332.9 (107.7)	291.9 (57.1)	335.2 (54.7)	293.4 (31.0)	75

can make the small craft unstable. Commonwealth regulations set a daily quota of 150 conchs per licensed fisherman up to a maximum of 450 conchs per vessel (with three licensed fishermen onboard).

Revenues and Costs

Divers reported various economic objectives for their fishing trips. Broadly speaking, about two-thirds (67%) of the interviewees said that they wanted to reach a certain catch and/or income target (e.g., landing 80 pounds of octopus, making a small return in excess of costs). Another 25% of the interviewees wanted to maximize benefits (or catch as much as possible), and the remaining 9% either had either no explicit objective or miscellaneous objectives such as enjoyment or to try one's luck. Somewhat surprising, about 31% of the catch or income targeters said that they simply wanted to cover trip costs, which is consistent with finding of other socioeconomic studies of small-scale fisheries (Salas and Gaetner, 2004). Though recouping trip costs is crucial to cope with irregular fishing income, we believe that most cost defrayers longed for sufficient income not only to finance their next trip (i.e., cover costs) but also to satisfy basic household needs.

Diving operations gross returns per trip ranged from $75 to $700, averaging $251 (Table 6).[13] Fuel and oil expenses accounted for 61% of the nonlabor variable costs.[14] Diving boats used between 4 and 28 gallons of fuel per trip, averaging 11 gallons. Air refills and grocery expenses were responsible for 25% and 10% of the nonlabor variable costs, respectively. Ice costs were minor because less than 23% of the interviewees iced their catch. After deducting nonlabor variable costs (e.g., fuel, air refills, groceries, etc.), net returns per trip ranged from $15 to $600, averaging $169 (Table 6).

Remunerative Arrangements

The lay arrangement was the dominant income sharing mechanism. Under lay arrangements, capital and labor are remunerated based on a percentage of the net returns (gross revenues minus variable expenses) rather than a fixed wage. Lay arrangements are designed to cope with fluctuating catches and prices. They help spread production risk because the boat owner's labor obligations are reduced if catches are poor. Conversely, boat owners' returns are dampened when catches are bountiful making it harder to amass capital and discharge debts (Symes and Frangoudes, 2001). In addition to spreading risk, lay arrangements encourage and reward teamwork and productivity by making each crew member a partner in the enterprise (Acheson, 1981; Doeringer et al., 1986).

The survey showed that income sharing rules between capital and labor

[13]Divers also sell natural queen conch pearls but their occurrence is very rare. Pearls retail between $300 and $30,000 depending on their size and quality.

[14]When we asked if they would change the way they operated if gasoline prices rose significantly about 40% said they would. The most frequently cited coping mechanisms were to fish closer to shore and raise fish prices. Only one of the divers proposed reducing the size of the crew or switching fishing gears.

varied significantly and that these were not always clear cut, particularly when the boat owner was one of the divers (Boncoeur et al., 2000; Guillen et al., 2015). Just over half (51%) of the interviewees reported that boat owners did not receive a boat share; however, they acknowledged that crew members contributed when repairs were needed.[15] The two main reasons offered for ceding the boat share were crew co-ownership of the enterprise (kin-based enterprise) and meager returns. Another 21% of the interviewees stated that there was not an explicit boat share, but explained that, for owners of larger boats, the owner share implicitly accounted for an unspecified return on capital and/or an allowance for maintenance expenses. An additional 20% said that boat owners charged a fixed amount for upkeep that ranged from \$5 to \$55 per trip. Only 7% of the respondents reported that there was an overt boat share that ranged from 15% to 35%.

The distribution of income between owner-operators and crew was fairly egalitarian. By and large, owner-operator and crew shares were roughly inversely related to the size of the labor force. For example, in 2-person operations, the average owner operator share was about 55% (range 33–75%). About 67% of these operations reported an equal allocation of fishing income between owner-operators and crew. Similarly, in 3-person operations, the average owner-operator share was about 34% (range 25–50%).

About 71% of these operations reported that fishing income was equally split between owner-operators and crew. Interviewees argued that the egalitarian distribution of income helped motivate and fairly reward crew since diving is a dangerous and labor intensive activity. Divers said that they placed their lives at risk every time they went out fishing. In addition, they

[15]Forgoing boat shares has been documented in the Puerto Rican small-scale hook and line and trap fisheries (Agar and Shivlani, 2016; Agar et al., 2017). Similarly, Salazar Espinosa (2015) reports that artisanal fishermen in Chile often have their fishing income tied to their labor rather than to the provision of capital.

Table 5.—Fishing practices by coastal region.

Variable	East coast	North coast	South coast	West coast	Island-wide	Number of respondents
Number of trips (trips/wk)	4.6 (0.3)	3.7 (0.5)	4.3 (0.3)	4.7 (0.2)	4.5 (0.1)	81
Trip duration (h/trip)	6.6 (0.3)	7.4 (1.0)	6.3 (0.2)	6.4 (0.2)	6.5 (0.2)	80
Total crew (incl. captain)	2.7 (0.2)	2.0 (0)	2.4 (0.1)	2.3 (0.1)	2.4 (0)	81
Crew distribution (%)						81
1 member				2.8	1.2	
2 members	40.0	100.0	60.9	72.2	65.4	
3 members	46.7		39.1	22.2	29.6	
4 members	13.3			2.8	3.7	
Number of scuba divers	1.9 (0.2)	1.7 (0.2)	1.5 (0.1)	1.5 (0.1)	1.6 (0.1)	71
Frequency scuba divers (%)						71
One	28.6	33.3	50.0	54.8	46.5	
Two	57.1	66.7	50.0	45.2	50.7	
Three	14.3				2.8	
Number of tanks per diver	3.9 (0.2)	3.0 (0.4)	3.6 (0.3)	3.5 (0.2)	3.6 (0.1)	71
Frequency tanks per diver (%)						71
One			10.0	6.5	5.6	
Two		50.0	15.0	12.9	15.5	
Three	28.6		5.0	19.4	14.1	
Four	57.1	50.0	45.0	54.8	52.1	
Five or more	14.3		25.0	6.5	12.7	

Table 6.—Costs and earnings of diving operations by coastal region.

Variable	East coast	North coast	South coast	West coast	Island-wide	Number of respondents
Average landings (lb/trip)	94.9 (13.3)	53.3 (6.9)	45.3 (3.6)	46.4 (2.9)	55.5 (3.0)	78
Variable Costs (\$/trip)						
Fuel expenditures	68.7 (7.5)	65.7 (14.8)	42.5 (3.3)	41.1 (2.8)	48.4 (2.4)	81
Trailer fuel expenses	0.9 (0.6)	16.1 (6.4)	0 (0)	0.2 (0.1)	1.5 (0.5)	81
Ice expenditures	2.3 (1.3)	4.7 (2.9)	0.3 (0.2)	0.6 (0.2)	1.1 (0.3)	81
Bait expenditures	0 (0)	2.1 (2.0)	0.9 (0.7)	0.5 (0.4)	0.7 (0.3)	81
Air refill expenditures	26.1 (3.5)	12.3 (3.3)	19.9 (1.9)	20.1 (1.3)	20.5 (1.1)	81
Food expenditures	12.8 (1.5)	11.7 (3.9)	7.9 (1.1)	5.6 (0.7)	8.1 (0.6)	81
Other expenditures	0.3 (0.3)	4.3 (3.4)	1.2 (0.9)	0.0 (0.0)	0.8 (0.4)	81
Gross earnings (\$/trip)	410.7 (36.4)	225.7 (13.3)	192.0 (13.7)	230.2 (14.8)	251.1 (10.1)	78
Total variable costs (\$/trip)	111.8 (9.4)	113.6 (20.0)	73.0 (4.4)	68.9 (3.4)	81.4 (3.1)	81
Net earnings (\$/trip)	299.0 (33.5)	112.1 (8.7)	119.6 (12.9)	160.8 (14.4)	169.3 (9.6)	78
Fuel consumption (gallons)	16.3 (1.8)	12.0 (2.6)	9.5 (0.8)	9.3 (0.5)	10.9 (0.5)	71
Ice use (%)	40.0	71.4	13.0	16.7	23.5	81

noted that the income split was customary and that crew often contributed to the enterprise by bringing their own gear. Divers received a higher compensation than boat tenders because of their contribution to revenues.

The study estimated that the average owner-operator earned about $72 per trip ($58 median, $8–$235 range) whereas a crew member netted almost $61 per trip ($50 median, $5–$235 range).[16] Occasionally, crew members would receive additional compensation if the trip was particularly successful. Valdés-Pizzini (1985) reports that, in the early 1980's, an owner-operator (in a 2-person operation) would earn $90 ($205 in today's dollars) and his boat tender would make $30 ($68 in today's dollars) during a good trip.

Although these latter income statistics may not be strictly comparable because they are confined to the port of Puerto Real, they may still be reflective of declining labor returns owing to the heavy exploitation of inshore grounds and stricter regulations (e.g., hookah ban, seasonal closure, 350 conch trip limit). Matos-Caraballo (2009) reports that declining queen conch stocks in the 1980's forced divers to move into deeper waters (from 4–12 to 70 ft).

Crew responsibilities extended beyond fishing. About 58% of the respondents said crew members helped with various cleaning, maintenance, and repair chores. Most of these fishing related activities were unpaid. Agar et al. (2008) suggest that this unremunerated assistance arises from shared cultural values of mutual help. Only 10% of the respondents said that the crew helped finance trip-related expenses (e.g., fuel) and/or the purchase of crafts, engines, and/or gear.

Crew Composition, Recruitment, and Turnover

The composition of the crew was found to be dominated by non-kin. Boats were crewed with friends and acquaintances (63%), family members (28%), or some combination of both (10%). Crew was recruited from local or neighboring communities. While information on past crew structure is limited Valdés-Pizzini (1985) notes that, at least on the west coast of Puerto Rico, most divers owned their boat or the diving equipment (or both), whereas boat tenders were hired hands. Most of these divers grew up in fishing families, working on their family's trap and/or (deep-water snapper) vertical line operations but later transitioned to diving because of poor catches and working conditions.

There are several explanations for the prevalence of non-kin crew. One reason is that diving is a dangerous activity which favors recruitment decisions based on skill, teamwork, and compatibility rather than on kinship ties (Norr and Norr, 1974, 1978).

A second reason has to do with the dispersal and weakening of kinship ties (Symes and Frangoudes, 2001). Owner-operators reported that they fished with non-kin because many had no family members who fished. Several fishermen remarked that fishing families are increasingly discouraging their offspring from pursuing fishing because of the hardships of eking out a living. In addition, respondents noted that higher educational attainment, widening vocational aspirations, greater occupational mobility, and out-migration (to the continental United States) no longer made fishing an "occupation of choice or necessity" (Symes and Frangoudes, 2001; van Ginkel, 2001; Symes, et al.,2015).[17] A number of captains stated that they did not differentiate between kin and non-kin crew because the latter were considered part of the family stressing the importance of affective social relations (Sonvisen et al., 2011).

Respondents reported that capable divers and boat tenders were hard to come by. About 54% of the respondents said it was difficult to recruit divers, 3% held it was challenging, and an additional 17% stated it was easy. However, 27% could not answer this question because they were unfamiliar with the labor market since they had long-term relationships with their non-kin crew or relied on kin. Roughly 51% of the interviewees thought it was difficult to find crew and another 23% said it was easy. However, as in the case of the question dealing with diver recruitment, almost 18% could not provide an answer.

Crew members exhibited a high degree of occupational fidelity. About 84% of respondents stated that they rarely employed new divers underlining the close-knit nature of the operation. Less than 2% of the divers surveyed stated that they employed at least one different diver on each trip. As one diver recounted, most individuals who became fishermen were born with the yearning for the fishing lifestyle. Close personal ties further cement these low turnover rates.

Efficacy of the Queen Conch Seasonal Closure

The final motivation of this study was to understand the degree to which the queen conch seasonal closure had proved useful. Fishing for queen conch is prohibited in Puerto Rico's jurisdictional waters from 1 Aug. through 31 Oct., and in the U.S. Exclusive Economic Zone year round with the exception of an area east of St. Croix, U.S. Virgin Islands.[18]

About 69% of the divers queried viewed the performance of the closure favorably, whereas the remaining felt its performance had either been fair or poor (Table 7). Divers who held a positive view believed that the closure had helped conch populations by allowing the stock to reproduce and grow.

[16]The Puerto Rican minimum wage rate was $7.25 per hour (Bureau of Labor Statistics, 2017b).

[17]Despite high migration rates to the continental United States, remittance proceeds from Puerto Ricans tend to be lower than other comparable migrant groups (Dominicans and Mexicans). Duany (2010) argues that Puerto Ricans are less generous because recipients back home have access to public assistance (e.g., nutritional assistance, housing subsidies) and entitlement programs (e.g., Social Security, Medicare, disability, and unemployment benefits) which act as a safety net much like remittances do in the Dominican Republic and Mexico. Hence, Puerto Ricans feel less compelled to send money back home.

[18]The Federal open season extends from 1 Nov. through 31 May.

Table 7.—Views about the performance of the queen conch seasonal closure by coastal region.

Variable	East coast	North coast	South coast	West coast	Island-wide	Number of respondents
Views about the efficacy of the queen conch closure (%)						81
Good	66.7	71.4	65.2	72.2	69.1	
Average	13.3	28.6	21.7	11.1	16.1	
Poor	20.0		13.0	16.7	14.8	

Nonetheless, they felt that better policing and compliance were needed.

By contrast, divers who thought that the closure had done a fair job felt that the closure had a minimal impact (if any) on conch populations. Many of the divers who felt that the closure performed poorly believed that it initially worked but no longer was effective due to the lack of compliance and enforcement. Moreover, they questioned the science behind the need and timing of the closure and underscored significant economic hardship brought about by the 3-mo closure. These divers also called for improved surveillance and enforcement.

Conclusion

Understanding the economic and social organization of the fishery can play an important role in the choice of policy prescriptions. Aside from describing user groups that may gain or lose from the policy changes, organizational knowledge can also inform and, potentially influence, policy by discerning and mapping interrelationships, feedback loops, and cumulative processes that impact the well-being of these groups (Pollnac et al., 2006). However, within a user group responses to policy changes can be complex and highly differential since they are influenced by, among other things, household demographics, capital investment, regulatory environment, accessible economic opportunities, and reference group behavior (Acheson, 2001).

This study found that the commercial dive fishery in the Commonwealth of Puerto Rico is composed of seasoned, small-scale commodity producers, who use labor intensive and low technology capital to catch a variety of high valued species. Divers were highly dependent on fishing which made them more likely to engage in dangerous fishing practices particularly if recent landings were low. The study also suggested that the risky nature of diving, the limited availability of able crew, and the dispersal and weakening of kinship ties were important reasons behind the reliance on non-household labor.

While there are no plans to amend existing fishery management plans, the findings from this study suggest that the imposition of restrictive regulations would bring about significant hardships on certain segments of the fishery, particularly on middle-aged fishermen who exhibited high degrees of fishing dependence and occupational fidelity. Even worse, as noted by one of the reviewers, restrictive regulations may encourage riskier (e.g., multiple long dives during the open season), and even deceptive practices (e.g., night diving to evade enforcement) to offset income losses.

Finally, the study found that safety remains a besetting problem underscoring the need to improve safety at sea. Besides making concerted efforts to educate and disseminate information about the risks of diving and encouraging best practices (e.g., planning dives, checking equipment, learning about personal physical limits, resting between dives, etc.), fishery managers could improve safety at sea by requiring diving certifications (or recertifications every number of years) to participate in certain fisheries such as the queen conch fishery, for which the Commonwealth already requires a dedicated permit (or endorsement). Fishery managers should also consider collecting data on injuries, accidents, and fatalities to assess the full impact of management actions and revise them as needed.

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Assessing a Long-Standing Conservation Program: Mariner's Perspectives on the North Atlantic Right Whale, *Eubalaena glacialis*, Mandatory Ship Reporting System

GREGORY K. SILBER and KRISTY WALLMO

Introduction

Policies and regulations established to protect the marine environment include measures to reduce perturbations of entire ecosystems (coral reefs: Bellwood et al., 2004), safeguard key habitats on large scales (Marine Protected Areas: Hoyt, 2011, IUCN-WCPA, 2008), and conserve marine species whose population sizes have declined to unsustainable levels (threatened or endangered species: NOAA, 2015). In the United States, the Endangered Species Act (ESA) provides legal protection for threatened and endangered marine (and terrestrial) species, while agencies including the National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (FWS), and, less frequently, the U.S. Coast Guard (USCG), are charged with developing and implementing strategies and actions aimed at recovering these species, most often through reduction of ongoing anthropogenic threats.

Establishing conservation actions may result in unintended economic or operational impacts, but subsequent assessments to determine whether they are meeting expected conservation objectives are few (Halpern, 2003; Selig and Bruno, 2010). Refining these actions through assessment and monitoring has the potential to improve both their conservation value and their cost-effectiveness (Bruner et al., 2004; Miteva et al., 2012).

In this paper we report findings from an online survey of the maritime industry designed to evaluate a Mandatory Ship Reporting (MSR) system—a long-standing program to raise awareness about and to reduce ship collisions with North Atlantic right whales, *Eubalaena glacialis*. Since 1999, provisions of the MSR have required ships weighing 300 gross tons (gt) or greater to report their location, speed, and destination to a shore-based station when entering key right whale nursery and feeding areas off the U.S. east coast.

In return, reporting ships receive a message, automatically generated, delivered directly to the ship's bridge, providing information about the risk of vessel collisions with right whales and actions mariners can take to avoid collisions (Silber et al., 2015). The MSR system is distinct from and predates other regulations in place to reduce ship collisions with right whales, such as ship speed reductions.

Our survey examined three aspects of the MSR system: 1) the degree to which mariners comply with the reporting requirements of the system, 2) the operational burden of compliance to captains and crew, and 3) their opin-

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ABSTRACT—Measures established to protect living marine resources, including those for endangered marine species, are only infrequently evaluated. In this paper we report findings of an online survey designed to solicit the views of maritime industries about a long-standing endangered large whale conservation program: the Mandatory Ship Reporting (MSR) system. The MSR was established in 1999 to aid in reducing the threat of vessel collisions with the highly depleted North Atlantic right whale, Eubalaena glacialis. *Under MSR provisions, vessels ≥300 gross tons are required to report their location, speed, and destination when entering two key right whale aggregation areas. In return, reporting ships are sent an automated message about right whale vulnerability to ship collisions. The survey was intended to obtain views about the extent to which vessel operations were interrupted by the reporting requirement; how mariners utilize, if at all, information provided in the return message; whether vessel operations were modified in response to guidance provided; and the overall importance and effectiveness of the reporting systems in helping ships avoid right whale interactions.*

A total of 119 mariners with broad representation of vessel types and decades of experience at sea took part in the survey; 56 of these indicated they had entered one of the MSR areas at least once. Most (ca. 70%) indicated that they comply with the reporting requirement, distribute information on right whales and ship strikes to crew members, that they were more alert about avoiding/watching for right whales, and that the ships operation may change to avoid an interaction. Of the survey-takers who had entered the system, about half indicated the MSR system is useful for educating captains and crew about right whales and important for right whale conservation, but only about a quarter indicated that it is useful in helping ships avoid right whales. About 40% said it is an unnecessary requirement for ships. We conclude that as an outreach tool and a means to provide information directly to domestic and international mariners entering right whale habitat for over 15 years (thus, tens of thousands of ships entering these waters have received the message), the MSR almost certainly has been beneficial in educating mariners about the issue of ship strike and in providing guidance on avoiding ship strikes. Views reflected in the survey suggest that, at least from the mariners' perspective, the MSR program has provided positive conservation value; however, not all mariners took specific strike avoidance action after having received the message.

ions about the utility of the system for reducing collisions and raising awareness about right whale conservation. Though several studies have focused on maritime industry compliance with large whale conservation regulations such as ship speed reduction in seasonally and dynamically managed areas (Lagueux et al., 2011; Asaro, 2012; Silber et al., 2014), few have examined the effectiveness of these regulations in reducing ship-whale collisions (Silber and Betteridge, 2012; Laist et al., 2014; van der Hoop et al., 2014). Further, none of these studies utilized data or observations from mariners themselves.

To date, only Reimer et al. (2016) have collected data directly from mariners in a survey about receptivity to real-time conservation technology. That study found that most mariners surveyed would be interested in receiving information on endangered whales and whale alerts via ships Navigational Telex (NAVTEX) and Automatic Identification Systems (AIS), and that most believed that receiving this information would not be disruptive to their operations (Reimer et al., 2016).

To our knowledge no study has examined mariners' perceptions of existing whale conservation measures and their utility in reducing the likelihood of ship-whale collisions. Our study directly addresses this gap regarding one such conservation measure by directly canvassing mariner viewpoints on use and compliance with reporting into the MSR, its overall conservation value, and impact on ship operations. Our findings add to the limited literature on the burden and overall utility of actions aimed at conserving large whales.

Survey results suggest the conservation value of the MSR program is likely positive because mariners indicated it raised awareness about the whale-strike issue. However, because the intent of the program is to provide information only, and not all mariners altered operations after receiving guidance in the return message, the overall biological impact of program may be somewhat limited.

Background of Ship-Whale Collisions and the MSR System

Most large whale species were the focus of intensive commercial hunting and were severely depleted globally. Although a number of these populations began to rebound not long after an international moratorium on commercial whaling in 1985–1986[1], unintended ship-whale collisions and other threats to population recovery remain. In the case of the North Atlantic right whale, population growth has been slow and deaths caused by violent strikes from large ships and fatal entanglement in commercial fishing gear are among the main impediments to recovery of this species (Clapham et al., 1999; Kraus et al., 2005; NMFS[2]).

North Atlantic right whales occur near and migrate along the eastern seaboard of Canada and the United States, where large human population centers and co-occuring water-borne commerce, commercial fishing, and other activities are also concentrated. Right whale feeding/socializing aggregation areas occur in waters off New England and eastern Canada and in nursery areas off the South Carolina to Florida coasts. The right whale is vulnerable to collisions with vessels throughout its range, but the threat may be particularly high in these aggregation areas where substantial vessel traffic also occurs (NMFS[2]).

Recognizing the influence of human activities on the recovery of right whales, the international community began taking steps to reduce the impact of these threats in the 1990's. Not all ship operators, and maritime commerce industries as a whole, were familiar with the risk that vessels underway posed to right whales and other large whale species. Thus, the conservation community began addressing this concern by focusing primarily on raising mariner awareness about the issue.

Among these actions was the creation of two Mandatory Ship Reporting systems (MSR) as a means to reduce the occurrence of "ship strikes" with right whales (Silber et al., 2015; USG[3]). A proposal initiated by the United States, backed by other nations and publicly endorsed by President William J. Clinton in April 1998 (Clinton, 1998), to establish the MSR was submitted to the International Maritime Organization (IMO) in June 1998. It was approved by the IMO in December 1998. This was the first formal IMO action to reduce the threat of ship collisions with whales (Luster, 1999), and its first formal action on behalf of any endangered marine species (Johnson, 2004).

Operation of the MSR

The goal of the MSR is to provide timely information about ship-whale collisions directly to individual vessels as they enter key right whale feeding and nursery habitats. Under the system, ships are required to report their location and time of entry into the system; in return, each reporting ship receives an automated message providing information on ways to reduce the chances of a striking a whale.

Under the rule, self-propelled commercial ships ≥300 gt are required to report to shore-based stations when they enter either of two regions off the eastern U.S. coast where and when right whales are known to occur: one off the state of Massachusetts operates year-round; the other, off the states of Georgia and Florida, is operational annually from 15 Nov. through 15 Apr. (Silber et al., 2012a) (hereafter, referred to as WHALESNORTH and WHALESSOUTH, respectively) (Fig. 1).

Incoming messages are sent primarily via satellite and include ship

[1]International Whaling Commission. Catch limits and catches taken (https://iwc.int/catches).

[2]NMFS. 2005. Recovery plan for the North Atlantic Right Whale (*Eubalaena glacialis*). U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Off. Protect. Resourc., (http://www.nmfs.noaa.gov/pr/pdfs/recovery/whale_right).

[3]U.S. Government. 1998. Ship reporting systems for the eastern coast of the United States. Proposal submitted to the IMO's Sub-Committee on Safety of Navigation. Online at http://www.nmfs.noaa.gov/pr/pdfs/shipstrike/imo_proposal.pdf.

name, course, speed, and destination among other things. Only reporting is required; no other changes to vessel operations are required. An automatically-generated message is returned to the reporting vessel that includes information on locations of recently-sighted right whales; procedural guidance to help prevent vessel-whale collisions; and information regarding protecting right whales from vessel strike (Fig. 2). Only vessels entering the prescribed areas are required to send a report, therefore only these vessels receive the automatic return message.

Following IMO endorsement, the USCG issued a Final Rule in the U.S. Federal Register (USCG, 2001) that codified the systems by amending the U.S. Code of Federal Regulations (33 CFR 169). The National Oceanic and Atmospheric Administration (NOAA) then added the MSR areas to relevant nautical charts and incorporated the new requirements into various navigational aids such as the U.S. Coast Pilot and elsewhere.[4]

The two MSR systems became effective on 1 July 1999 and have been in operation continuously since that time. From July 1999 to present, operation and administration of this program have been jointly run by the USCG and NOAA's NMFS. All ship-to-shore and shore-to-ship communication costs are borne by these two agencies (including a government contract to the communications provider).

Reporting data from these systems have been useful in characterizing vessel operations within the areas (Ward-Geiger et al., 2005), particularly as it relates to the recovery of right whales. Among other things, incoming MSR reports provided information on U.S. east coast port arrivals and vessel operations which helped form the basis for subsequent ship strike-reduction measures.

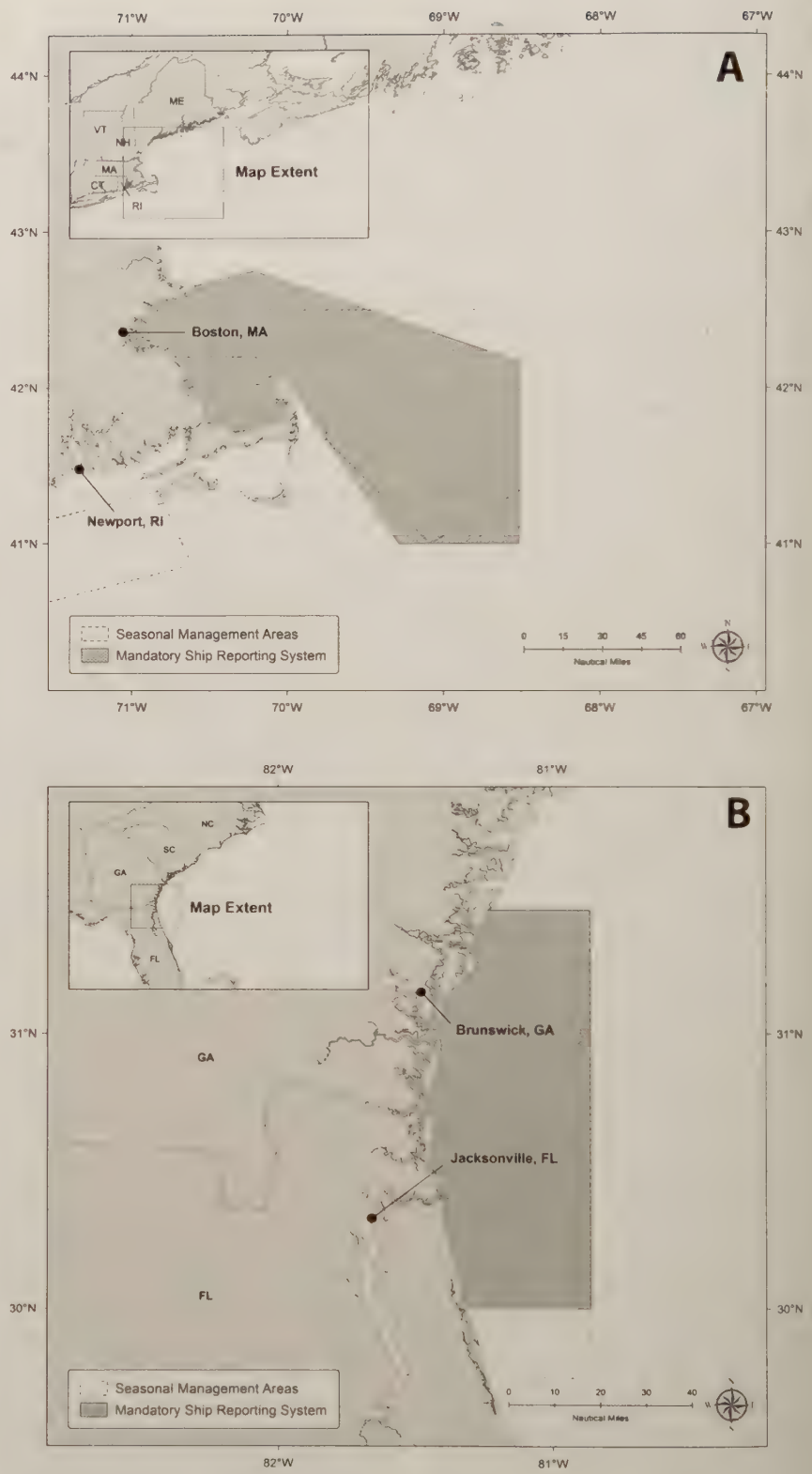

Figure 1.—Mandatory Ship Reporting System Area Boundaries. Also shown are vessel speed restriction seasonal management area boundaries (NOAA, 2008).

[4]See, for example USCG, Local Notice to Mariners. Coastal Waters from Eastport, Maine to Shrewsbury, New Jersey. Special Notices, No. 27/99. Online at http://www.nmfs.noaa.gov/pr/pdfs/shipstrike/uscg_lnm0799.pdf.

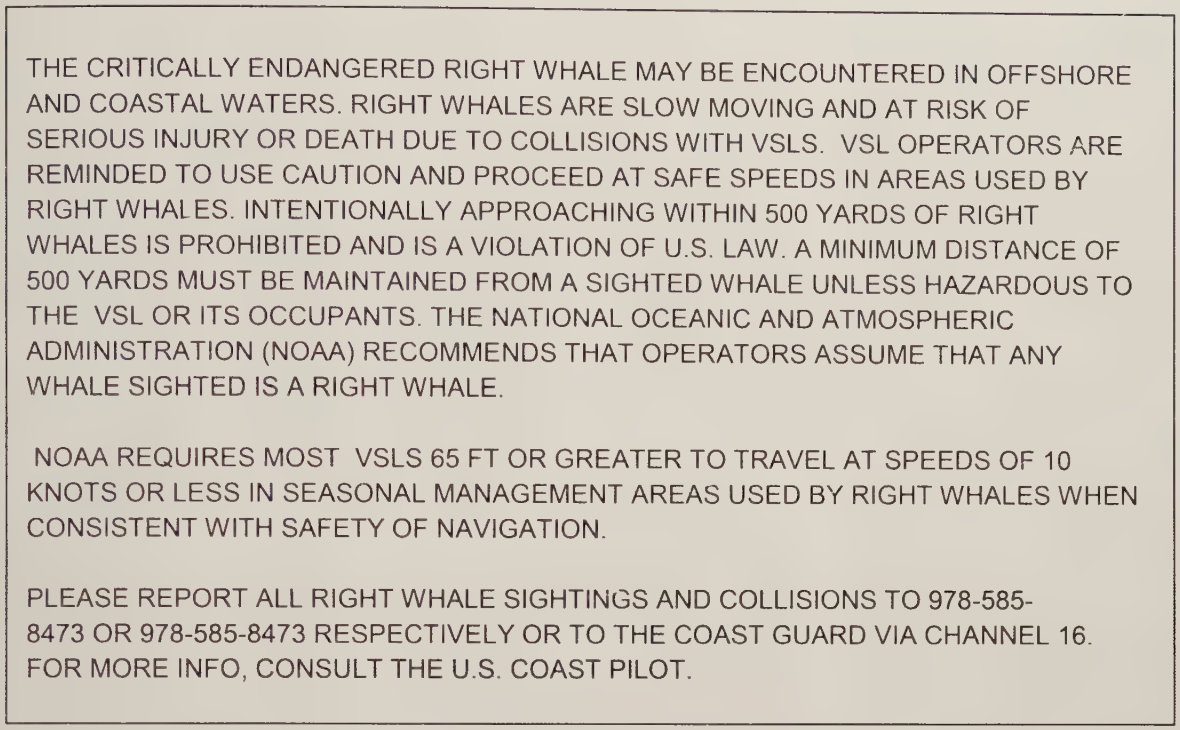
THE CRITICALLY ENDANGERED RIGHT WHALE MAY BE ENCOUNTERED IN OFFSHORE AND COASTAL WATERS. RIGHT WHALES ARE SLOW MOVING AND AT RISK OF SERIOUS INJURY OR DEATH DUE TO COLLISIONS WITH VSLS. VSL OPERATORS ARE REMINDED TO USE CAUTION AND PROCEED AT SAFE SPEEDS IN AREAS USED BY RIGHT WHALES. INTENTIONALLY APPROACHING WITHIN 500 YARDS OF RIGHT WHALES IS PROHIBITED AND IS A VIOLATION OF U.S. LAW. A MINIMUM DISTANCE OF 500 YARDS MUST BE MAINTAINED FROM A SIGHTED WHALE UNLESS HAZARDOUS TO THE VSL OR ITS OCCUPANTS. THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) RECOMMENDS THAT OPERATORS ASSUME THAT ANY WHALE SIGHTED IS A RIGHT WHALE.
NOAA REQUIRES MOST VSLS 65 FT OR GREATER TO TRAVEL AT SPEEDS OF 10 KNOTS OR LESS IN SEASONAL MANAGEMENT AREAS USED BY RIGHT WHALES WHEN CONSISTENT WITH SAFETY OF NAVIGATION.
PLEASE REPORT ALL RIGHT WHALE SIGHTINGS AND COLLISIONS TO 978-585-8473 OR 978-585-8473 RESPECTIVELY OR TO THE COAST GUARD VIA CHANNEL 16. FOR MORE INFO, CONSULT THE U.S. COAST PILOT.

Figure 2.— USCG Mandatory Ship Reporting System WHALESNORTH automated return message.

A recent 15-plus-year retrospective analysis of incoming reports (Silber et al., 2015) determined that hundreds of individual ships made over 45,000 reports into the system between July 1999 and December 2013. While generally regarded as a successful and valued outreach tool, the current study is the first attempt to gauge the attitudes and perceptions of mariners regarding conservation benefits as well as the potential impacts to reporting vessels, and to evaluate the ongoing utility and relative value of this long-standing program.

Materials and Methods

An online survey was developed by NMFS economists and biologists during June–August 2014 to collect data on mariner awareness, attitudes, and use of the MSR system. Because the sampling strategy was opportunistic with an unknown universe, an important consideration in the survey design was to minimize the overall survey length and develop clear and concise questions. To help ensure that these considerations were met and that the overall survey was easy to comprehend, a draft instrument was tested in a focus group on 17 Sept. 2014 in Baltimore, Md., at the Maritime Institute of Technology and Graduate Studies/Pacific Maritime Institute (MITAGS-PMI).

Focus group participants were recruited from a pool of mariners who were attending a course at MITAGS-PMI and agreed to participate in a voluntary discussion about the MSR system and the survey. Based on feedback from the focus group, a final survey instrument was developed that contained eight questions and an opportunity to provide open-ended comments at the end of the survey.

The survey (Appendix I), which was implemented online in early June 2015, was programmed by a private consulting firm, ECS Federal[5], and hosted on a domain purchased specifically for the survey implementation. The target survey population was ship owners, operators, or captains who had entered either WHALESNORTH or WHALESSOUTH one or more times.

During an average year, several thousand separate trips are made into both areas (Silber et al., 2015) (some ships and masters may enter multiple times per year). The information needed to directly contact individual ship captains, owners, and/or crews to conduct a survey is not available, making a sampling frame infeasible to develop. For this reason, an opportunistic or convenience sample was necessary.

We acknowledge that this type of sampling has a number of limitations, including the inability to a) examine response bias, b) compute statistical errors, and c) make inferences to a larger population. However in our case, due to the lack of individual contact information, an opportunistic sample involving broad outreach to the generalized community was the only

[5]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

viable approach for contacting vessel operators. Ferber (1977) noted that while opportunistic samples are less desirable than samples derived from a systematic approach, they have utility for exploratory purposes or to obtain different views on the dimensions of an issue or problem.

To implement the survey, federal and private entities who engage in activities or communicate regularly with maritime entities were asked to distribute information about the survey (Appendix II). Announcements of the availability of the survey were also sent via association and government email distribution lists shortly after the survey opened.

The announcements of the survey provided potential respondents with a brief description of the survey, why their participation was important, and a link to the online survey. Two additional announcements about the survey were distributed in August and September 2015.

Respondents who chose to participate in the survey were asked eight questions. The first set of questions asked about familiarity with the MSR system and their ship transits through the MSR areas. The second set of questions asked about compliance with, burden of, and conservation potential of the MSR system. The remaining questions asked for the number of years in the industry and type of ship the respondent currently worked on (container ship, passenger vessel, etc.). The survey remained open through 10 Jan. 2016, at which time the URL for the survey was deactivated. The analysis included simple frequency counts of responses to each question.

Results

Respondent Characteristics

A total of 119 mariners took part in the survey. Of this number 85 respondents said they were aware of the MSR system (34 people who accessed the survey but entered no response whatsoever or indicated they had no experience or were not familiar with the MSR, were excluded from the analysis) and 56 indicated they had entered one of the MSR areas at least once.

Due to the publicity of the MSR and its support from the IMO, it is possible that mariners who have never entered one of the MSR areas were still familiar with the system and the reporting requirements, and therefore we considered a total of 85 survey-takers eligible to answer a subset of the survey questions. Questions that required direct experience and use of the MSR were only shown to respondents who stated they had entered an MSR area at least once.

Among the 85 respondents who were aware of the MSR, representation of vessel types was broad, and included container ships, tankers, cargo or bulk carriers, RO-RO's (i.e., car and vehicle carriers), cruise ships, passenger vessels (i.e. ferries, whale watching vessels), research ships, and pleasure craft. According to Rodrigue et al. (2017) the global maritime industry has about 100,000 vessels (>100 t) consisting of passenger, bulk carrier, general cargo, and roll-on/roll-off vessels; about 69% of shipping ton-miles is accounted for by bulk carriers. Our sample consists of captains and crew from all four types of vessels, and about 53% of respondents cited they worked on bulk carriers.

The years of service in the maritime industry ranged from 2 to 48 years, with 23% working less than 20 years and 77% working more than 20 years. The average number of years respondents have worked in the maritime industry was 26, with an average of 11 years as a crew member and 11 years as a captain.

Of the 56 respondents indicating they had entered one of the MSR areas at least once, about 44% said they entered one of the areas regularly. The number of times respondents said they entered one of the areas during a year ranged from 1 to 100, with a mean of 27.8. About 35% (n=20) indicated they enter WHALESNORTH most frequently, 29% (n=16) entered the WHALESSOUTH most often, and 35% (n=20) indicated they enter both areas about the same amount.

As noted, our data is based on an opportunistic sample of ship captains and crew. While the vessel types in our data are representative of the types of vessels in the maritime industry as described by Rodrigue et al. (2017), we cannot determine whether respondent's opinions and attitudes toward the MSR system are representative of those of the larger industry, and specifically those ships that transit the MSR areas.

Compliance with the MSR System

Most respondents comply with the reporting requirement of the MSR system. About 75% of respondents (n=42) stated that they send the required report always or most of the time; and slightly less than a fourth of them (24%) said they rarely or never send the report. About 82% (n=46) of respondents stated that they receive a return message about right whales after sending in their ships' report, while the remainder (n=10) indicated they did not receive a return message via the system.

Survey-takers were asked about their level of agreement with four statements related to the transmittal of required ship information when entering an MSR area: 1) it is relatively easy to send in the required report, 2) I generally follow the report format exactly as specified in the instructions, 3) I send in the report as soon as possible, and 4) sending in the required report takes time away from other duties I have on the ship. Of those responding to this portion of the survey, half (n=20) indicated it was easy to send in the report, with over 70% stating that they followed the required format and they sent in the report as soon as possible after entering the area. About half said that sending in the report takes time away from other duties on the ship (Fig. 3).

Attitudes Toward the MSR System

Following these statements respondents were asked about their level of agreement with four statements related to the automated right whale conser-

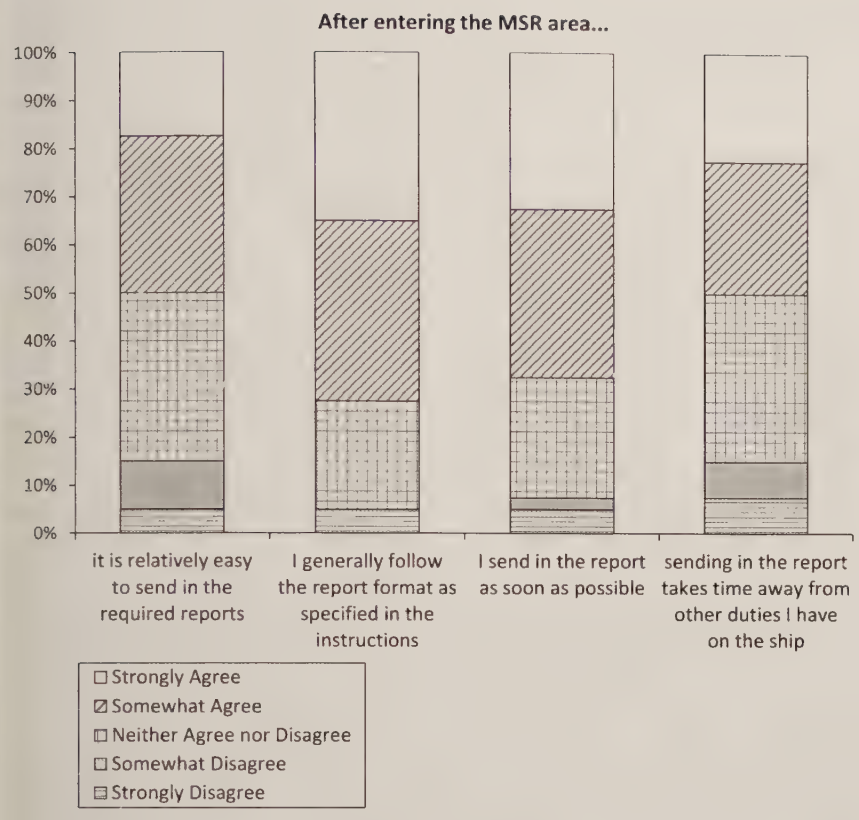

Figure 3.—Attitudes toward Mandatory Ship Reporting system ship requirements.

vation information they receive after reporting into the system: 1) I generally don't have time to read the entire message, 2) I am more alert about avoiding or watching for right whales, 3) I find the information to be useful for the captain and crew, and 4) some aspect of the ship's operation may change (e.g., speed, post extra lookouts) to avoid an interaction. Among those responding to all the questions in this section of the survey (n=25), 60% don't read the entire message, but over half said they are more alert about avoiding/watching for right whales and may change the ships operation to avoid an interaction. Nearly 80% of respondents stated they distributed the information in the message to captains and/or crew (Fig. 4).

All respondents who stated that they were aware of the system (n=85), even if they had not entered an MSR area, were asked about their level of agreement with four statements concerning general perception of the MSR system: 1) the MSR system is important for right whale conservation, 2) is an unnecessary requirement for ships, 3) has been useful in helping ships avoid right whale interactions, and 4) is a useful system for educating captains and crews about right whales. Of those responding to this set of questions (n=64), over half (n=34) indicated the MSR system is useful for educating captains and crew about right whales and important for right whale conservation, only about a quarter said it is useful for helping ships avoid right whale interactions, and about 40% said it is an unnecessary requirement for ships (Fig. 5).

In regard to the written comments portion of the survey, several respondents provided additional views about the importance of the MSR in the context of endangered whale conservation; others said it had little utility in reducing strikes of whales. A few of those providing comments reiterated that reporting into the systems was not a significant or time-consuming task, some suggested using alternative vessel tracking systems in lieu of the MSR. Apparently, a number of respondents believed the survey to include discussion of vessel speed restrictions in addition to the MSR, while others took the opportunity to comment on right whale vulnerability (or their lack of vulnerability) to ship collisions, the utility of right whale protective measures generally, or to offer suggestions on ways to diminish the impact of right whale conservation on maritime industries.

Discussion

The invitation to participate in the survey was distributed on a broad scale, and we believe that hundreds of mariners were at least aware of the survey. However, the exact number of individuals who received notification of the survey remains unknown; therefore, a response rate is also not known. We expected the number of respondents to be a small fraction of the total number reached for several reasons.

First, previous studies (Ranmuthugala et al., 2008) have shown that opportunistic sampling generates relatively low responses relative to the number of individuals targeted through broadly cast notification efforts, and there was likely considerable overlap in the entities described in Appendix II.

Second, not all mariners are familiar with the MSR program, because a) it applies only to ships sailing in waters along parts of the U.S. eastern seaboard; b) of these, not all ships enter certain U.S. east coast ports (e.g., Boston, Mass., Jacksonville, Fla.) where MSR areas are situated; and c) not all ships meet the 300 gt threshold for reporting. And, finally, there is little reason to expect ship captains sailing under a non-U.S. flag to complete a voluntary survey focused on a U.S. policy implemented by U.S. Federal agencies.

The nature of an opportunistic sam-

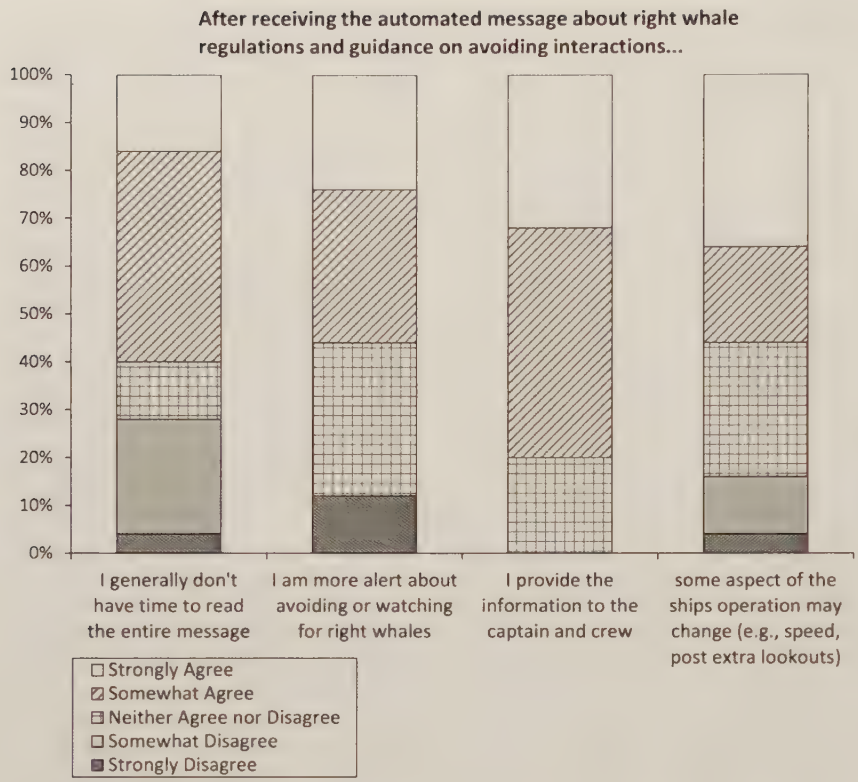

Figure 4.—Attitudes toward Mandatory Ship Reporting system automated return message containing right whale information.

ple implies that the findings are not generalizable to a larger population nor can the extent of response bias be formally identified (Pruchno et al., 2008). Previous studies comparing opportunistic samples to random samples are rare (Pruchno et al., 2008). Two studies that have compared variables of interest between these two sampling approaches suggest that sample means on variables of interest were significantly different between opportunistic and random samples (Pruchno et al., 2008; Ranmuthugala et al., 2008); thus we suggest that the results best represent only those individuals in our survey sample population.

Comments provided via the survey were varied: some indicated an awareness regarding the vulnerability of right and other whales to ship strikes, the severity of the problem, and the need to reduce this threat; others indicated that reporting, and other measures, were not needed. However, we note that responses about the efficacy of the MSR may have come from mariners who had not actually entered the systems.

A number of respondents confused the MSR with a more recent action to reduce ship collisions with right whales: seasonal vessel speed restrictions (NOAA, 2008). This is consistent with findings regarding the number of reports made incorrectly outside the boundaries of the MSR systems; namely, reporting into MSR systems was common along vessel-speed restriction seasonal management area boundaries which are unrelated to the MSR (Silber et al., 2015).

Speed restrictions likely have greater economic and operational impact to commercial maritime industries—as well as having a more quantitative, documented influence on reducing vessel strikes of right whales (Conn and Silber, 2013; Laist et al., 2014; van der Hoop et al., 2014; Martin et al., 2016)—than does the MSR because the latter involves reporting only. Therefore, some mariners may have used the survey as an opportunity to express their views about the speed restrictions.

Our results are mixed on the ease of use of the MSR system by mariners. Of respondents with direct experience with the system, about 70% followed the reporting requirements and sent the report as soon as possible after entering an MSR area, and only 15% indicated the reporting requirements were difficult to follow. However, about half of respondents felt that sending the report took time away from other duties and nearly 60% said that they did not have time to read the entire return message. In addition, about 40% of all respondents felt the MSR system is an unnecessary requirement for ships.

As a conservation measure, our results suggest that the most important function of the MSR is one of education and raising awareness, as most respondents with direct experience with the program indicated that information in the return message was distributed to their crews and that crew members were generally more aware of right whales after receiving the information. Further, about half of all respondents (including those without direct MSR experience) stated the system was good for whale conservation and considered the system a good way to raise awareness about ship-whale collisions.

Being a metric difficult or impossible to reasonably quantify, mariners, of course, cannot know the overall impact of the MSR in reducing collisions with whales. However, the goal was to attempt to ascertain whether mariners disregarded the incoming message, for example, or whether their possible actions in response to some aspect of the message may have lowered the possibility of striking a whale.

Respondents were roughly equally divided in their views on whether the system was useful in avoiding

whales. Thus, there is little doubt that the MSR has served to raise mariner awareness about the depleted status of right whales and the species' vulnerability to ship collisions because hundreds of ships have made tens of thousands of reports to (and received return messages from) the MSR in the period since its implementation (Silber et al., 2015).

Inasmuch as return messages arrive in the bridge of reporting vessels as they enter right whale habitat, this feature alone has served as a frequent reminder to those operating ships in U.S. waters about an important conservation matter—and in this regard the outgoing message has been a flexible informational tool for alerting mariners about additional large whale conservation measures as they have been developed.

More broadly, an important aspect of the MSR, a feature with international implications, is that its establishment, as one of the first formal measures to address the threat of ship-whale collisions (Johnson, 2004), helped facilitate the development of additional whale conservation measures. For example, since the implementation of the MSR, the United States and several other nations have established related IMO-adopted routing measures in their waters (Silber et al., 2012a).

In addition, outgoing MSR messages have been adapted to provide alerts about other threat-reduction measures (e.g., dynamically implemented and seasonal vessel speed restrictions) and have been used to provide written information on right whale sightings. However, in regard to information dissemination, broad-based distribution programs have also been developed by a number of entities. For example, a number of ports and government agencies now rely on a number of systems (e.g., the frequently updated USCG Broadcast Notice to Mariners) to transmit information to ships, including information about right whale sightings.

The International Whaling Commission provides brochures for mariners regarding large whale ship strikes[6]; numerous non-governmental organizations maintain web sites and actively distribute information on this matter; and NMFS has developed and routinely provides interactive CD's, laminated cards, and booklets[7] regarding the threat of ship strikes of right whales.

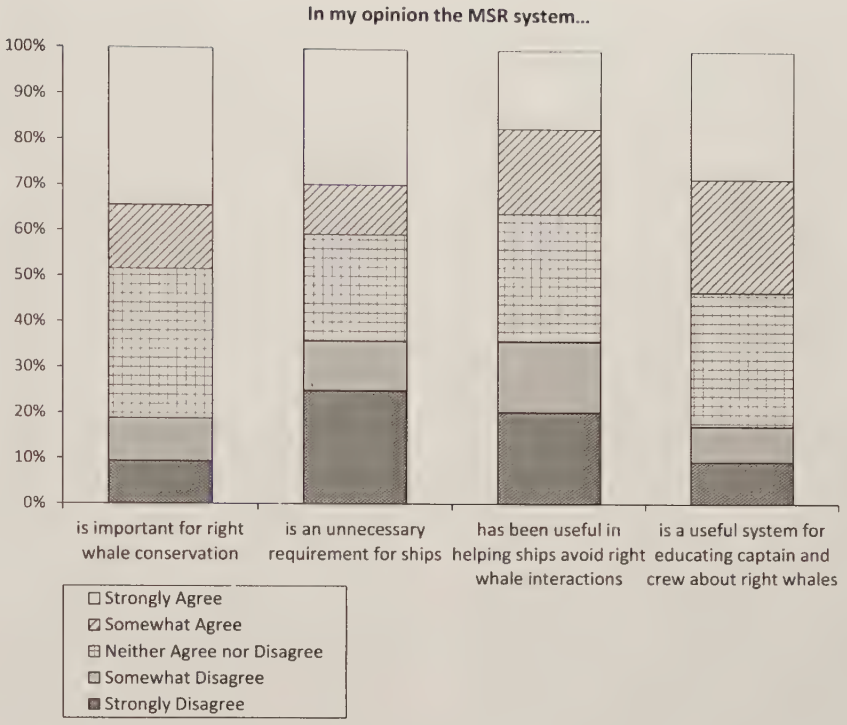

Figure 5.—General attitudes toward the Mandatory Ship Reporting system.

Most of this material, however, is "passive" and has neither the immediacy of notifying ships directly through the MSR nor provides near real-time information about sighted whales. And, while various outlets provide near real-time whale sighting information through interagency cooperative efforts (NOAA, 2006), it is not clear if, and to what extent, mariners consult and use this information.

Our results from respondents with direct experience with the MSR indicate that the system may have some utility for directly reducing the number of whale-ship collisions, as over half stated that they are more alert after receiving the incoming MSR message and about half said some aspect of the ships operation may change as a result of the message. About 35% of all respondents stated that the MSR is useful for helping ships avoid right whale interactions. Nonetheless, information on the number of known right whale deaths from ship collisions is noted below and in van der Hoop et al. (2014), and no discernable differences are apparent in fatal strike rates in the time after sighting information was routinely provided beginning in the mid-1990's via aircraft survey programs and through the MSR beginning in 1999. Therefore, the extent to which whale sighting information provided via the MSR, or any other means, plays a role in reducing the number of ship struck whales is not clear.

[6]Whales: collisions prevents damage to ships, and injuries to passengers, crew and whales. (https://iwc.int/index.php?cID=3199&cType=document).

[7]Interactive items online at www.greateratlantic.fisheries.noaa.gov/protected/shipstrike/training/index.html.

One of the stated secondary purposes of the MSR was to enable the gathering of data to facilitate a better understanding of vessel operations in right whale habitat as a means to further develop conservation measures (Merrick and Cole, 2007; Silber et al., 2012a). When the MSR was established, routinely collected and archived information on vessel operations on this scale did not exist.

However, since inception of the MSR, advancing technologies are used to monitor vessel activities. In regard to monitoring U.S. port entries, systems to track vessel operations and emerging reporting requirements are far more comprehensive and precise than self-reporting under MSR protocols. Among the most important of these is the advent and use of GPS-linked VHF radio signal and satellite-transmitted Automatic Identification Systems (AIS) which are required on most ships and broadcast signals that provide detailed information on ship location, speed, and routes (Vanderlaan and Taggart, 2009; Reimer et al., 2016; Robards et al., 2016). In addition, a number of U.S. ports have Vessel Tracking Systems to aid in navigation, and some fishing vessels are required to carry Vessel Monitoring Systems.

Following the attacks of 11 September 2001, all vessels have been required to provide 96-h notice prior to calling on a U.S. port. Some of these technologies, AIS in particular, have been used to assess changes in ship operations in response to the implementation of various whale protection measures, including routing scheme changes (Vanderlaan and Tagart, 2009; Lagueux et al., 2011), vessel speed restrictions (Lagueux et al., 2011; Wiley et al., 2011; Silber et al., 2014), and dynamically managed areas (Silber et al., 2012b). Development and use of these technologies and communication systems have rendered the MSR a less than optimal means to gather and relay information to and from ships and have therefore largely supplemented the tracking of ship operations functions of the MSR.

From 1999 (when the MSR was established) to June 2016, 11 confirmed right whale deaths resulted from collisions with ships (Laist et al., 2014; Henry[8]), an average of 0.7 per year. This rate of known deaths attributed to ship strikes is roughly comparable to the 10 years prior to implementation of the MSR (1990–99; 0.6 per year); but the average decreased to 0.3 fatal strikes per year in the years 2007 through 2015 (Laist et al., 2014; Henry et al.[5]).

A number of factors could be involved in affecting these rates. We contend that variables such as whale distribution and shifts in distribution, particularly relative to large-scale shipping lanes, and overall shipping traffic volume, play roles in the occurrence and frequency of whale strikes. In the last decade, for example, the number of large vessel trips into U.S. east coast ports has fluctuated in response to shifting economic climates and increasing ship size and cargo capacities (the latter being a feature that reduces the number of trips overall) (DOT, 2013; MARAD, 2013; Silber et al., 2015).

In the context of these pervasive circumstances influencing the economics of transporting goods on worldwide scales, education and outreach efforts, while still important, may have little overall effect on rates of fatal ship strikes. Regardless, while the rather crude metric of annual deaths lacks sufficient resolution to fully evaluate the effects of the MSR, we note only that there were no immediate or overt changes in right whale ship strike-related death rates at the onset or in the time the MSR was in place.

Protection of living marine resources can be challenging in light of resource utilization by multiple industrial or commercial users. Conservation measures are generally established by incorporating the best available science and with maximum (practical) protections in mind. But such programs are not always evaluated (Clark et al., 2002; Ferraro and Pattanayak, 2006) or assessed to identify ways to optimize use of limited resources (Kapos et al., 2008) or fully utilize the provisions of available statutes.

The U.S. Government has faithfully operated the MSR for years and there is little doubt the program has conservation benefits by raising awareness of the maritime industry. Further, the MSR is one element in a suite of ship strike reduction measures that include IMO-adopted Areas To Be Avoided (Vanderlaan and Taggart, 2009), modifications of shipping routes (USCG, 2007), and voluntary and mandatory vessel speed restrictions (NOAA, 2008). However, our survey results suggest that, at least from the perspective of mariners who completed our survey, benefits of the MSR in reducing the likelihood of ships colliding with right whales are divided, but had a role in promoting education and outreach opportunities.

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[8]Henry, A. G., T. V. N. Cole, L. Hall, W. Ledwell, D. Morin, and A. Reid. 2014. Mortality determinations for baleen whale stocks along the Gulf of Mexico, United States east coast, and Atlantic Canadian provinces, 2008–12. U.S. Dep. Commer., Northeast Fish. Sci. Cent., Ref. Doc. 14-10, 17 p. (https://www.nefsc.noaa.gov/nefsc/publications/crd/crd1410).

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Appendix 1.—Mandatory Ship Reporting systems survey instrument.

Right Whale Mandatory Ship Reporting System: What do you think?

The National Marine Fisheries Service, the federal agency responsible for the stewardship of living marine resources and their habitats, is sponsoring a survey to obtain mariner's feedback on the **North Atlantic right whale Mandatory Ship Reporting (MSR) system. (To find out more about the MSR system go here)**

This survey is only about the reporting system. It is **not** about the ship speed restrictions or any other right whale conservation program.

This is a voluntary survey. Your feedback will be used to evaluate and improve the MSR system. All survey responses are anonymous and confidential.

OMB Control No. 0648-xxxx. Expiration Date: xx/xx/xxxx. Public reporting burden for this information collection is estimated to average 10 minutes per response. Send comments regarding this burden estimate or other suggestions for reducing this burden to Kristy Wallmo, 301-427-8190 or Kristy.Wallmo@noaa.gov.

Responses are kept confidential as required by section 402(b) of the Magnuson-Stevens Act and NOAA Administrative Order 216-100, Confidentiality of Fisheries Statistics, and will not be released for public use except in aggregate statistical form without identification as to its source. Notwithstanding any other provisions of the law, no person is required to respond to, nor shall any person be subjected to a penalty for failure to comply with, a collection of information subject to the requirements of the Paperwork Reduction Act, unless that collection of information displays a currently valid OMB Control Number.

1. Are you aware of the North Atlantic right whale MSR (MSR) system?
   - ❒ Yes
   - ❒ No. *If 'No' survey will skip to Q7.*

2. During the year, about how many times do you enter one of the MSR areas?
   - ❒ I enter one of the MSR areas on a regular basis

     If box above is checked, survey will prompt: Approximately _____ times per year
   - ❒ I have entered at least one of the MSR areas but not on a regular basis. Approximately _____ times.
   - ❒ I have not entered either of the MSR areas. *If checked, survey will skip to Q6c.*

3. Which MSR area do you enter most frequently?
   - ❒ North MSR area
   - ❒ South MSR area
   - ❒ About the same amount for both areas

4. When you enter a MSR area, how often do you send a report as part of the MSR system?
   - ❒ Always
   - ❒ Most of the time
   - ❒ Some of the time
   - ❒ Rarely
   - ❒ Never

5. After sending in a report to the MSR system, have you received a message about right whale regulations and guidance on how to avoid interactions with right whales?

   ❒ Yes

   ❒ No

6. Please check the box that best represents your level of agreement with each statement.

	Strongly Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Strongly Disagree
6a. After entering one of the MSR areas...					
...it is relatively easy to send in the required report	❒	❒	❒	❒	❒
...I generally follow the report format exactly as specified in the instructions	❒	❒	❒	❒	❒
...I send in the report as soon as possible	❒	❒	❒	❒	❒
...sending in the required report takes time away from other duties I have on the ship	❒	❒	❒	❒	❒
6b. After receiving the automated message about right whale regulations and guidance on avoiding interactions with right whales...					
...I generally don't have time to read the entire message	❒	❒	❒	❒	❒
...I am more alert about avoiding or watching for right whales	❒	❒	❒	❒	❒
...I provide the information to the captain and crew	❒	❒	❒	❒	❒
...some aspect of the ship's operation may change (e.g. speed, post extra lookouts) to avoid an interaction as a result of having received the message	❒	❒	❒	❒	❒
6c. In my opinion the MSR system...					
... is important for right whale conservation	❒	❒	❒	❒	❒
...is an unnecessary requirement for ships	❒	❒	❒	❒	❒
...has been useful in helping ships avoid right whale interactions	❒	❒	❒	❒	❒
...is a useful system for educating captains and crew about right whales	❒	❒	❒	❒	❒

7. How many years have you worked in the maritime industry? _____

   (a) How many years as a crew member? _____

   (b) How many years as a captain? _____

8. What type of ship do you work on? _____

Thank you very much for your participation in this survey. Your feedback will help NOAA Fisheries improve the North Atlantic Right Whale MSR system. Please add any additional comments you have concerning the MSR system in this box.

Type comments here

Appendix 2.—Communications channels used to notify users of an online survey of Mandatory Ship Reporting systems.

Federal Agencies

NOAA's Ocean Service. Regional Navigation Managers work directly with pilots, mariners, port authorities, and recreational boaters to help identify and address marine transportation system navigational safety issues. Based on our request, U.S. east coast navigation managers used their regular public and industry meetings, port facility functions, and other conduits to notify mariners about the survey.

National Geospatial Agency (NGA). The NGA's *Notice To Mariners* (msi.nga.mil/NGAPortal/MSI.portal?_nfpb=true&_st=&_pageLabel=msi_portal_page_61,) is the principal publication for ships engaged in international voyages. Designed to ensure the safety of life at sea, this publication provides marine safety information and corrections to navigational aids for all U.S. Government navigation charts and publications derived from a variety of sources, both foreign and domestic. A special notice about the survey was posted in the NGA's Hydrogram and Marine Information sections of the weekly notice on 10 June 2015 (msi.nga.mil/MSISiteContent/StaticFiles/NAV_PUBS/UNTM/201525/Marine_Info.pdf) and again on 3 September 2015.

Maritime Administration (MARAD). The Department of Transportation's MARAD is charged with ensuring that the nation maintains adequate shipbuilding and repair services, efficient ports, and reserve shipping capacity for use in time of national emergency (www.marad.dot.gov/). It promotes maintenance of a well-balanced U.S. merchant fleet for transport of waterborne commerce, and it is capable of service as a naval and military auxiliary in time of war. MARAD promoted the MSR survey with an announcement via its distributions list, containing perhaps several thousand active mariners. Announcement by email distribution sent on 27 July 2015.

NOAA, NMFS, Northeast Regional Office. Participating members of maritime contact distribution lists were encouraged via email to take the survey by shipping industry liaisons from both NOAA's NMFS Southeast and Northeast Regional Offices on 7 July 2015. The survey was also discussed by liaisons at numerous industry meetings.

U.S. Coast Guard (USCG). The USCG's outreach program posted a blog about the survey on 6 November 2015. On average, the blog receives approximately 40,000 unique (each coming from a different IP address) views per month.

Industry Associations

World Shipping Council (WSC). With 26 companies, which utilize hundreds of ships and employ hundreds of vessel operators, the WSC represents over 90% of global liner vessel capacity and transport cabilities. At our request, the WSC sent notifications to all of its member companies on two occasions (28 July and 30 August 2015).

Chamber of Shipping of America (CSA). The CSA represents 35 U.S.-based companies that own, operate, or have commercial interest in oceangoing tankers, containers, and dry bulk vessels engaged in domestic and international trades. These entities employ hundreds of vessel operators. The CSA sent notifications about the survey to each of its member companies on two occasions (15 July and 8 August 2015). The CSA also asked a number of other industry associations to notify their members; these included InterTanko, American Waterways Operators (AWO), Cruise Lines International Association (CLIA), International Chamber of Shipping (ICS), and Baltic and International Maritime Council (BIMCO).

Just for information: InterTanko has 204 members and 236 companies whose combined fleet comprises some 3,077 tankers; AWO is the national trade association for the U.S. tugboat, towboat, and barge industry; CLIA is the world's largest cruise industry trade association; ICS membership represents national shipowners' associations in Asia, Europe, and the Americas whose member shipping companies operate over 80% of the world's merchant tonnage; BIMCO is the largest of the international shipping associations representing shipowners and its membership controls around 65 percent of the world's tonnage.

Passenger Vessel Association. The PVA represents companies who are owners, operators, and leasers of shipboard operations of passenger vessels on the waterways of the United States and Canada including car and passenger ferries, tour and excursion vessels, charter boats, eco-tour boats, and day sailing vessels. These vessels move over 200 million passengers each year. The PVA sent notification of the MSR survey to all its members on 5 August 2015.

Maritime Periodicals

Mariner's Weather Log. A publication of the National Weather Service (NWS), this journal (http://www.vos.noaa.gov/mwl.shtml) allows the NWS to maintain contact and communicate with over 10,000 shipboard observers worldwide. It is used to distribute meteorological information, worldwide environmental impact concerns, climatology studies, and the like to the maritime community. A special announcement (including a small story and photograph) appeared in the August 2015 (Vol. 59, No. 2) issue (www.vos.noaa.gov/MWL/201508/msrsurvey.shtml)

Editorial Guidelines for the *Marine Fisheries Review*

The *Marine Fisheries Review* publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to the *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under a completed NOAA Form 25-700 (available from the SPO website).

Manuscripts must be double-spaced throughout, and a complete manuscript normally includes a title page, a short abstract, text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, headings, subheadings, and the abstract short and clear. Because abstracts are circulated by abstracting agencies, it is important that they represent the research clearly and concisely. Headings within each section must be short, reflect a logical sequence, and follow the rules of multiple subdivision (i.e., there can be no subdivision without at least two items).

Style

The entire text should be intelligible to interdisciplinary readers; therefore, all acronyms, abbreviations, and technical terms should be spelled out the first time they are mentioned. The scientific names of species must be written out the first time they are mentioned; subsequent mention of scientific names may be abbreviated. Follow the U.S. Government Printing Office Style Manual (2008 ed.) and the Scientific Style and Format: the CSE Manual for Authors, Editors, and Publishers (2014, 8th ed.) published by the Council of Science Editors.for editorial style, and the most current issue of the American Fisheries Society's Common and Scientific Names of Fishes from the United States and Canada for fish nomenclature. Only journal titles, scientific names (genera and species), and vessel names should be italicized. Dates should be written as follows: 11 November 2013. Measurements should be expressed in metric units, e.g., metric tons as (t); other equivalent units may also be listed in parenthesis. Common abbreviations and symbols such as mm, m, g. ml, mg, and °C (without periods) may be used with numerals. The numeral one (1) should be typed as a one, not as a lower-case el (l). Write out the numbers zero through nine unless they form part of measurement units (e.g., nine fish but 9 mm).

Footnotes

Footnotes should not be embedded within the text document. They must be numbered with Arabic numerals and listed separately. Footnote all personal communications, unpublished data, and unpublished manuscripts with full address of the communicator or author, or, as in the case of unpublished data, where the data are on file. Authors are advised to avoid references to nonstandard (gray) literature, such as internal, project, processed, or administrative reports, wherever possible. Where these references are used, please include where they may be located (website or public depository).

Tables

Tables should be printed separately and double-spaced. Tables should not be excessive in size and must be cited in numerical order in the text. Headings should be short but ample enough to allow the table to be intelligible on its own. All unusual symbols must be explained in the table heading. Other incidental comments may be footnoted with Arabic numerals. Because tables are typeset, they need only be submitted typed and formatted, with double-spaced legends. Zeros should precede all decimal points for values less than one. Table headings and format should be consistent; do not use vertical rules.

Literature Cited

Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, and the year, month, volume, and issue numbers of the publication. Citations should be double-spaced and listed alphabetically by the senior author's surname and initials. Co-authors should be listed by initials and surname. Where two or more citations have the same author(s), list them chronologically; where both author and year match on two or more, use lowercase alphabet to distinguish them (1979a, 1979b, 1979c, etc.). Authors must double-check all literature cited; they alone are responsible for its accuracy.

Digital object identifier (doi) code ensures that a publication has a permanent location online. Doi code should be included at the end of citations of published literature.

Figures

Figures must be cited in numerical order in the text. Use Times Roman font (upper and lowercase letters) to label within figures. Avoid vertical lettering except for y-axis labels. Zeros should precede all decimal points for values less than one. Figure legends should explain all symbols and abbreviations and should be double-spaced on a separate page at the end of the manuscript. Consider column and page sizes when designing figures. Please note that we do not print graphs in color.

Finally

Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission.

Email or mail the manuscript to: Editor, Marine Fisheries Review, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Seattle, WA 98115 (Willis.Hobart@noaa.gov and cc: the Managing Editor, Jacki.Strader@noaa.gov).

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